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Water Problems in Glass Manufacture

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(*Written for* THE GLASS INDUSTRY)

Water has been called the universal solvent, on account of its ability to dissolve small amounts of practically every substance with which it comes in contact. The purest water found in nature is the water vapor of the clouds. As this water falls in the form of rain it commences its solvent action, and by the time it has reached the earth it is carrying in solution a certain amount of oxygen and carbon dioxide. These two substances render it capable of greater dissolving action, and as it passes over or through the crust of the earth it continues to dissolve small amounts of the various substances it meets on its way, so that when it is finally taken up for industrial use it is really a weak solution of a number of substances.

There is practically no water available for industrial use which does not contain small amounts of sand, of iron, and of the carbonates, sulphates and chlorides of calcium (lime) magnesium and sodium. It is these dissolved substances which cause most of the trouble experienced in the use of water for industrial purposes, although if perfectly pure water could be obtained it would still cause trouble for certain industrial uses, for its solvent action would cause corrosion. Hence it is true that for many uses there is practically no natural supply of water known but that can be improved upon by suitable treatment.

In the glass industry there are two major uses to which water is put. The more important of these is the generation of steam for power and for heat. The other is the use of water as a cooling agent. In both of these cases the water comes into contact with heat, and very nearly the same considerations apply, although in a different degree, to the troubles experienced from an unsatisfactory water supply.

Before going further into the troubles experienced from imperfect water let me introduce very briefly the methods in use today to overcome these troubles. In the order of the length of time they have been in use they are (1) boiler compounds, (2) precipitation water softeners, (3) zeolite water softeners.

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BOILER COMPOUNDS

Ever since the pressure boiler first came into use and scale was formed by the evaporation of water, the engineer has been adding various substances to the feed water in the hope that it would prevent this scale or make it easier to remove. It is only within comparatively recent years that the manufacture of boiler compounds has been placed on a scientific basis, and accurate chemical engineering knowledge has taught the manufacturers to scientifically diagnose the trouble by chemical analysis of the water and by up-to-date engineering analysis of the conditions under which the water was used. Even today for every manufacturer of high-grade scientific boiler compounds there are many manufacturers of quack nostrums and cure-alls, the counterfeiters and mountebanks of the water purification field. In this discussion, however, I shall refer exclusively to the reputable, progressive and scientific manufacturers of boiler compounds when I speak of their use in the treatment of water.

PRECIPITATION WATER SOFTENERS

A little over two decades ago there was perfected in this country a water purification apparatus known as the water softener, whereby the scale forming and corrosive matter from the water could be precipitated out in a large tank by the addition of chemicals, the precipitate allowed to settle out, and the softened water drawn off through a filter. The chemicals used were very common and cheap—ordinary lime and soda ash. This was a distinct advance in the problem of water purification and these water softeners gained a wide distribution, and for the most part have given and are giving satisfactory results. The advantages and disadvantages attendant upon their use are discussed later in the article.

ZEOLITE WATER SOFTENERS

More recently there has been developed an entirely different type of water softener, known as the zeolite water softener, operating upon an entirely different principle from the precipitation water softener, eliminating some of the disadvantages of the latter, but possessing certain disadvantages

which the earlier type of machine did not possess. The zeolite water softener consists in essence of a pressure filter whose filtering medium is a zeolite—a complex chemical compound, insoluble in water and in appearance resembling a fine gravel or coarse sand. This zeolite is highly charged with sodium in a very active state; and when water containing calcium or magnesium salts is percolated through a bed of zeolite this sodium is exchanged for the calcium and magnesium, molecule for molecule, so that when the water has passed through it has lost practically all of its hardening substances and is softer than rain water. After a time this available sodium is all used up, and then the bed of zeolite is soaked for a sufficient length of time (which varies with the products of the various zeolite manufacturers) in a brine made of common salt (sodium chloride) where a reverse action takes place, the zeolite giving up the calcium and magnesium it has absorbed and becoming recharged with the active sodium. As soon as this brine has been rinsed out the zeolite is again ready for its daily task of softening water. The advantages and disadvantages of this type of water softener will also be pointed out later on in this article.

Let us now turn to the troubles caused by impurities present in water supplies and the way in which the remedies are applied in order to be most effective.

Boiler Scale

Let us consider first the use of water for the production of steam for boiler feed. There are three major troubles experienced here, one or more of them being found in practically every boiler using the natural water without treatment. They are, in the order of their importance, boiler scale, foaming and priming, and corrosion.

Boiler scale will form, to a greater or less degree, from over 95% of all of the water supplies in America. It is caused by a combination of two conditions. First and more important is the fact that many of the substances dissolved in water cannot remain in solution under boiler conditions, but are precipitated out, cementing themselves to the surface of the boiler and of the boiler tubes. Some substances which thus precipitate out do not of themselves possess this cementing ability but they are caught in the matrix which does so fix itself on the boiler metal and they add to the amount of scale. Second is the fact that with constant evaporation of the water and withdrawal of the steam the concentration of the substances present in the water is constantly increasing, and although in the original water some of these substances might remain in solution under boiler conditions, the concentration passes the point of their saturation, so that with all subsequent evaporation a proportionate amount of the substances will crystallize out of solution and will also affix themselves to the sides and the tubes of the boiler as scale.

There are two principal reasons why boiler scale is highly undesirable, and both of them grow out of the fact that it is a very efficient insulator to heat. First we may consider heat as a fluid in motion; it flows through the boiler shell into the water, causing it to evaporate. Boiler scale increases the resistance to this flow, and as with any other fluid, to maintain the same flow against greater resistance it is necessary to increase the pressure. The only way of increasing the pressure for the flow of heat is by building a hotter fire—by burning more coal. The accompanying table, prepared by Prof. Schmidt of the University of Illinois, will give some idea as to the loss of coal caused by various thicknesses of boiler scale.

Horse power of boiler	Yearly cost of coal with clean boilers	Extra cost (or loss) each year caused by scale, according to thickness				
		1/32"	1/16"	1/8"	1/4"	1/2"
100....	$2,624	$222	$324	$486	$740	$1,190
200....	5,248	444	648	972	1,420	2,380
300....	7,872	666	972	1,456	2,220	3,570
400....	9,000	762	1,114	1,666	2,540	4,070
500....	9,376	794	1,162	1,734	2,646	4,250
750....	11,250	952	1,392	2,080	3,174	5,100
1,000....	15,000	1,270	1,860	2,774	4,232	7,990
1,250....	18,950	1,588	2,320	3,466	5,290	8,490
1,500....	22,500	1,904	2,782	4,158	6,350	10,200
2,000....	30,000	2,540	3,718	5,546	8,464	13,604

Second, when there is a heat insulation medium between the boiler shell and the water the boiler shell naturally is not only subjected to greater heat to force the B.t.u's. through the shell and the scale into the water, but by robbing the boiler shell of the cooling action of the water it becomes hotter still. This decreases the life of the boiler shell and of the boiler tubes very materially, allowing them to burn out in a much shorter length of time, thereby necessitating more frequent renewals, with the accompanying shutdown of the boiler and the expense of making the repairs.

The action of boiler compounds in preventing the formation of scale is twofold. Certain chemicals are used which precipitate the scale-forming matter more rapidly than it could be precipitated by the heat, causing it to come down in the form of a sludge which can be taken care of in the blowoff. Supplementing the action of these chemicals, other chemicals are used which coat the particles of sludge with a slippery coating, thereby preventing any possibility of their adhering to the boiler.

Both types of water softener operate upon the principle of removing the scale-forming matter before the water enters the boiler. From a strict scientific standpoint this is theoretically the better method of handling the problem; but there are frequently practical difficulties which militate against the perfect operation of scale prevention in this manner, as for instance the causing of other troubles than scale by the softening of the water.

Foaming and Priming

Second only to boiler scale, the greatest trouble experienced from the water in the boiler is known as foaming and priming. Foaming is the carrying over of wet steam, while priming is the carrying over of water with the steam. The only difference is one of degree, priming being merely an aggravated form of foaming.

These troubles may be caused by a number of conditions, probably the most important being too high concentration of certain salts in the boiler. Next to this is the presence of a great deal of suspended matter in the boiler water. Usually foaming and priming are caused by a combination of the two conditions. Other conditions which cause foaming are the presence of oil in the water, usually introduced by the condensate, and the fact that some boilers are built with inadequate steam space.

There are three effects from foaming and priming which make them extremely undesirable. First, wet steam has not

the expansive qualities of dry steam and hence this causes a loss of power in the engine. Second, on account of the constant evaporation, the water in the boiler is constantly becoming more concentrated and therefore carries a larger proportion of dissolved matter than does the feed water. Hence, when minute droplets of this concentrated solution are carried over with the steam unless the steam passes through a superheater they settle in the valves and on the inside surfaces of the steam spaces of the engine. This leaves a deposit which in time necessitates the regrinding of the valves, and scores the cylinder and the piston rod, causing steam leaks and thereby a loss of power. Third, if the steam passes through a superheater these droplets of boiler water are completely evaporated, but they form a deposit in the superheater which impairs its efficiency, in addition to the fact that this deposit is frequently of a corrosive nature and in time will destroy the superheater itself.

The prevention of foaming and priming depends largely upon the cause. If the trouble is from concentration of the boiler water, the logical remedy is to change the water in the boiler oftener and to blow down more frequently. If it is suspended matter, the blow-down will again answer the question—only in this case more effective blowing down is more important than greater frequency. With most if not with all boilers, a series of short blows is much more effective than a single long blow, although many operating engineers do not realize this. Where the trouble is caused by oil, the logical cure is to install an oil separator.

It is sometimes found to be the case, however, that the raw water used carries a sufficiently high concentration that foaming and priming cannot be economically prevented by blowing down and by changing the water, for these changes of the water would have to be made so frequently as to greatly reduce the efficiency of the boiler. In cases such as this, the logical method of prevention is to use an anti-foam. Most manufacturers of high-grade boiler compounds also manufacture anti-foams and some even incorporate anti-foaming chemicals in all of their compounds designed to treat waters whose analysis shows that they would be likely to cause foaming.

CORROSION

There are many causes of corrosion in boilers, most of them being due to dissolved matter in the feed water. Small amounts of acid or of iron or aluminum sulphates are violently corrosive, out of all proportion to the amount present. These substances are rarely met with except in coal mining or iron smelting districts, and are easily taken care of either by the use of boiler compound or by treating the water through the precipitation water softener. Such waters cannot be handled by the zeolite water softener.

Probably the most widespread cause of corrosion in boilers is the presence of magnesium chloride in the water. Any water which contains an appreciable amount of this salt or of magnesium sulphate and sodium chloride (for under boiler conditions magnesium chloride would be formed from this combination) is likely to cause corrosion. Treatment by any of the three methods will eliminate the magnesium chloride, and will prevent the corrosion.

Corrosion is occasionally caused by electrolytic action. Such corrosion is rarely met with in stationary boilers, but is nearly always present in marine boilers. The most effective method of combating electrolytic corrosion is by the use of zinc. This zinc is frequently used in the form of slabs, bolted to the boiler stays, and forming an electric connection with them. The zinc, being electro-positive to the steel of the boiler is corroded in place of the steel, thus protecting the boiler. One manufacturer of boiler compounds has made use of this property of zinc by using finely powdered zinc in his compounds intended for use where electrolytic corrosion is found. This eliminates the necessity for the use of the zinc plates, and has proven very successful.

Corrosion is frequently met with in steam pipes—especially in dead-end spaces—in economizers, etc. This is usually due to the presence of carbon dioxide in the water, and sometimes to the presence of sodium carbonate which breaks up under high-pressure boiler conditions, liberating free carbon dioxide. This type of corrosion is best combated by treating the water chemically, either by the use of boiler compounds or through the precipitation water softener. The zeolite water softener would be likely to increase rather than diminish this type of corrosion.

This is the type of corrosion usually found where water is used for cooling purposes, as in water jacketed apparatus. Experiment has shown that iron submerged in water containing dissolved carbon dioxide will corrode very rapidly, while in the total absence of any free carbon dioxide the corrosion proceeds very slowly, or the iron is not corroded at all. Furthermore, once started the corrosion seems to gather speed, for the carbon dioxide seems to act merely as a catalytic agent (that is, it merely acts as a lubricant, allowing the reaction to proceed without itself taking any chemical part in the reaction, and not being used up) and there seems to be no limit to the amount of corrosion that can be caused by a very small amount of the carbon dioxide. The logical way out of this trouble, then, is to remove all carbon dioxide from the water before it enters the water jacket. This may be done by chemical treatment. All free carbon dioxide has been eliminated from water treated through a precipitation water softener, and any boiler compound designed for the purpose of the prevention of this trouble will completely remove it from the water. So far as the actual results achieved are concerned, there is little to choose between the two methods of treatment. The zeolite water softener does not remove the carbon dioxide from the water, and consequently cannot be used for the prevention of this trouble.

GENERAL DISCUSSION

In the face of the claims and counter-claims set up by the manufacturers of the various types of water purification apparatus, it is frequently difficult for the layman and the plant superintendent to decide which method of treatment is bested suited to his particular problem. In an article of this nature it is obviously impossible to spend any time in considering individual cases, but it is the author's intention to outline a few of the general considerations that he himself uses in advising his clients as to the particular apparatus best suited to their individual needs. Probably the best way to do this will be to outline briefly the advantages and dis-

advantages of each of the three common types of treatment.

I.—The outstanding advantages of boiler compounds are as follows:

1. It is not necessary to install any expensive apparatus.
2. The simple apparatus which is necessary for feeding is simpler and easier to handle than is the precipitation water softener, and it is more flexible in operation than is the zeolite water softener.
3. A greater variety of chemicals may be used, thereby frequently producing better results than could be obtained with either type of water softener.
4. There is no loss of water due to backwashing filters, disposal of sludge, washing out brine, etc.
5. Foaming and priming may be more successfully overcome than with any other method.

The principal disadvantages are:

1. It is frequently difficult to obtain uniform treatment of all of the water used.
2. The scale forming substances are precipitated in the boiler instead of outside, forming more mud and rendering more careful watching of the blow-off necessary.
3. On account of the increase in the amount of sludge collecting in the boiler it is necessary to blow down more frequently. This causes a loss of heat, and when the boiler is under pressure at the time of the blow down, a lowering of the pressure.
4. The actual cost per thousand gallons of water treated is frequently greater than is the case with softened water. This is to a certain extent offset by the depreciation and interest on the investment in the softener.

The argument most frequently met with in opposition to the use of boiler compounds is that it makes a water softener out of the boiler. While this is of course true, there is no good reason why the boiler should not function as a water softener as well, provided it can at the same time perform its usual duty without impairing its efficiency. That this is frequently the case is attested by the fact that many of the largest and most progressive users of steam power continue to use this method of treatment for their feed water.

The weakest point in the case for the use of boiler compound is the fact that it causes a greater amount of mud to settle out in the boiler than do either of the other methods of treatment. The importance to be attached to this point must be determined by local conditions, and by the personal preferences of the operating engineer.

II.—In the case of the precipitation water softener, the following advantages are most important:

1. Cost per thousand gallons of water treated (ignoring interest on investment, depreciation, etc.) is frequently, if not usually, lower than with either of the other methods.
2. Capacity is not affected by the hardness of the water, as is the case with the zeolite water softener.
3. The treated water carries a smaller amount of dissolved matter than does the raw water. This decreases, to a certain extent, the danger from foaming and priming.
4. The limits of hardness which can be successfully treated is greater than is the case with the zeolite water softener, but not than with the boiler compound method.
5. It is unnecessary to pre-filter muddy water before treating, as is the case with the zeolite water softener. It is not absolutely necessary, but it is highly preferable to pre-filter muddy water when treating with boiler compound, to prevent the excess of mud being carried into the boiler.
6. Water softened by this method does not cause as great an accumulation of mud in the boiler as does water treated with boiler compound, rendering blowing down less frequently necessary.

The principal disadvantages are:

1. Its operation is more complicated and it requires more expert attention than either boiler compound or the zeolite water softener.
2. It requires more space than any other type of water purification.
3. It is frequently difficult to dispose of the large amount of sludge formed, on account of the tendency of the sludge to collect and block sewers. The large amount of water necessary to wash the sludge away adds to the cost of operation.
4. The high first cost of the apparatus and the constant care that must be given to any complicated piece of machinery add to the cost of treating the water.

There are two strong points brought out in arguments against the precipitation water softener, and they are the high first cost and the necessity for expert attention. The first cost is less than that of a zeolite water softener of the same rated capacity, as a general rule, but the operation of the zeolite water softener is much simpler and more "fool-proof."

When a precipitation water softener is given the proper attention it will usually deliver a very high grade of boiler feed water, and one that will not cause corrosion either in the boiler or, when used for cooling, in the water jacket. The precipitation water softener has proved successful and very satisfactory in thousands of installations. Its greatest success has been achieved with boilers that show the least tendency to foam, for the slightest over-treatment increases the danger of foaming very greatly.

III.—Turning to the zeolite water softener, its strongest points are:

1. By eliminating practically all of the scale forming matter from the water, it produces a boiler feed water which cannot form scale.
2. It is much simpler in operation and requires much less attention than the precipitation water softener, and very little if any more than does boiler compound.
3. No chemicals are fed into the water. There is no changing of amounts of chemicals on account of fluctuations in the hardness of the water.
4. It requires much less space than does the precipitation water softener, but a great deal more space than the feeding device for boiler compound.

Its weakest points are:

1. The first cost in most cases is greater than with either of the other methods of treatment.
2. The amounts of sodium salts in the water and the total amount of dissolved matter is increased, which increases the danger from foaming.

3. Any change in the hardness of the water produces a proportionate change in the capacity of the softener.

4. It will not remove carbon dioxide from the water, hence it is of no value in the prevention of corrosion from this cause.

5. Any noticeable amount of iron or manganese in the water will soon ruin the filter bed and render it incapable of softening water.

There are two principal arguments in favor of the zeolite water softener, and two against it. Those in its favor are the ease and simplicity of operation, and the fact that it will absolutely prevent the formation of scale. Those against it are the increase in the danger of foaming and the fluctuation in its capacity. There is another item, not mentioned above, which frequently militates against its use, and that is the fact that there are many waters which it cannot successfully handle on account of the hardness or on account of high sodium content.

General Summary

Taking everything into consideration, the use of boiler compound is probably the least expensive and most adaptable treatment, though not in every case the most satisfactory.

On large installations, where the proper care and attention can be given it, with a moderately hard water and with boilers carrying an ample steam space, the precipitation water softener finds its most effective field.

Under similar considerations, with a moderately soft water, the zeolite water softener shows up at its best.

Under conditions which are likely to cause foaming and priming, the zeolite water softener will increase the danger; the precipitation water softener requires unusually careful watching, while the boiler compound finds one of its most congenial fields.

With a corrosive water the zeolite water softener is eliminated from consideration, while boiler compounds and the precipitation water softener share the honors.

In closing, however, I wish to call attention to the fact that each separate case *is* a separate case and brings into the problem its own peculiarities. Where space is as limited as in an article of this character, it is only possible to touch lightly upon the most salient features of a field to which a lifetime could be devoted without exhausting the possibility of new discoveries. If, however, the reader is able to fit into the mosaic of his own conditions certain of the generalities given above, then this article will have fulfilled its purpose.

Street Lighting Glassware*

By S. L. E. ROSE†

It is self evident that we can never get more light from a unit than is given by the lamp used in the unit. In fact, adding equipment such as reflectors, refractors, globes, etc., always reduces the total lumens given by the unit.

The efficiency of a lamp is expressed in lumens per watt.

The efficiency of a complete unit, however, is usually expressed as per cent of bare lamp lumens and is obtained by dividing the total lumens of the unit by the total lumens of the lamp. Thus, if the lamp gives 1,000 lumens and the complete unit gives 800 lumens, the efficiency of the unit is 80 per cent.

The efficiency is affected by the type of fixture used, the size of reflector, and the nature of the reflecting surface as well as the thickness and density of the glassware. As each piece of equipment is added some of the light from the lamp is lost. It should be noted, however, that an internal reflector in some units will increase the light from the unit as a whole by decreasing the loss in the housing or metal canopy.

If the efficiency of the unit were the only consideration we would use bare lamps to light our streets but other factors enter into the problem, such as the necessity of protecting the lamp from rain and snow, average intensity on the street surface and midway between units, glare, appearance, etc., which make it necessary to use accessories in order to get the best results.

We must sacrifice some of the light from the lamp in order to get certain desired results; in other words, we must lose some light from the lamp in order to increase the utilization efficiency or increase the æsthetic value. In fixtures using paneled globes, shown in Figs. 1 and 2, the loss is greater than where a one-piece globe is used, due to the frame and ribs that form the panels. The ornamental feature is of primary importance here and efficiency of secondary consideration.

If we change from a small reflector to a larger one, from clear glass to diffusing glass, or from light density glass through which the light source is visible to a denser glass which conceals the source and gives better diffusion, we must lose some light, but if by the change we can accomplish the purpose we are striving for, then the loss is justified and compensated for by the superior results obtained.

From the foregoing remarks it is seen that the total loss in a lighting unit is made up of the sum of the losses in the various parts that compose it.

There are various kinds of glass used for globes and each kind may be obtained in different weights or densities. These are usually marketed under trade names which convey no clear idea of the quality or appearance of the glass.

Certain types of globes from the same manufacturer and supposedly of the same kind may vary in light transmission due to varying thickness and density, which it is apparently difficult to eliminate altogether. Some of the factors influencing the transmission are the shape of globe, thickness of glass, density of diffusing media used in their manufacture, as well as the personal element that enters into their manufacture.

In comparing globes of different makes, where only one sample of each kind is tested, it is well to remember the influencing factors for glass manufacturers can vary the density within quite wide limits.

When selecting glassware, therefore, in addition to the transmission, other factors should be taken into consideration,

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such as general appearance of the unit when lighted and when out; also the ability to withstand handling and weather conditions met in practice.

With the older types of glass, such as opal, alabaster, carrara, and alba, the light source was visible and good diffusion could be obtained only by sacrificing transmission. With the newer glass, such as genco, the light source is not visible and good diffusion is obtained as well as high transmission and light weight. With rippled glass the light source is not visible and high transmission is secured.

In discussing globes they are usually spoken of as clear, light density, medium density, heavy density, etc., depending on their transmission. It is very difficult to draw any definite line between these different densities; *i. e.*, where "light

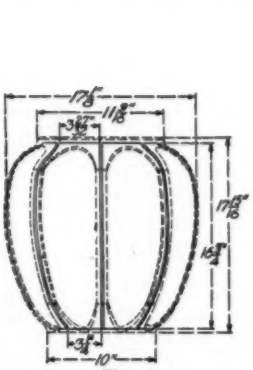


Fig. 1

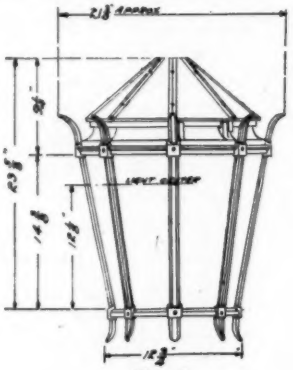
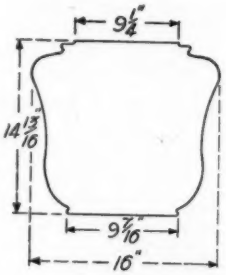


Fig. 2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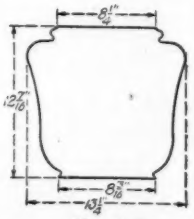
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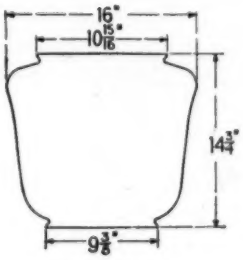
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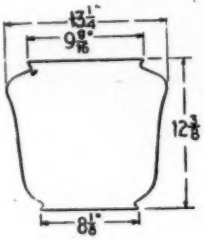
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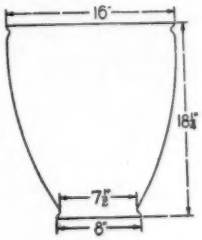
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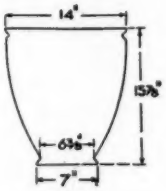
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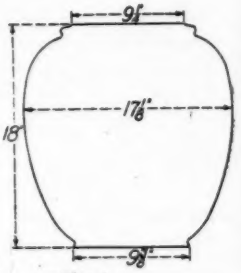


Fig. 9

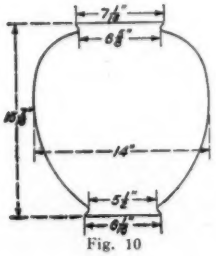


Fig. 10

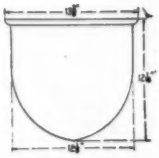


Fig. 11

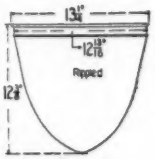


Fig. 12

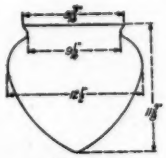


Fig. 13

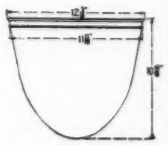


Fig. 14

FIGS. 1 TO 14. MODERN TYPES OF GLOBES FOR STREET LIGHTING

TABLE I—LIGHT TRANSMISSION LOSS IN GLOBES.

Type of Globe	Kind of Glass	Density Rating	Weight Lb.	Weight Oz.	Per Cent Loss
Fig. 11	Crystal	Clear	6	7	3.6
Fig. 11	Carrara	Light	6	9	17.8
Fig. 12	Rippled	Clear	4	12	10.3
Fig. 12	Rippled	R. I. & R. O.	5	6	25.5
Fig. 13	Crystal	Clear	4	8	4.2
Fig. 13	Carrara	Light	3	9	19.6
Fig. 14	Rippled	Clear	3	13	13.8
Fig. 4	Genco	Light	4	12	22.2
Fig. 6	Rippled	Clear	6	7	8.5
Fig. 6	Rippled	R. I. & R. O.	6	11	22.3
Fig. 3	Crystal	Clear	10	8	9.1
Fig. 3	Alba	Light	10	12	19.0
Fig. 3	Carrara	Light	11	4	17.9
Fig. 3	Carrara	Medium	12	12	31.2
Fig. 3	Alabaster	Light	9	8	17.9
Fig. 3	Alabaster	Medium	10	0	27.9
Fig. 3	Polycase	Medium	11	4	28.8
Fig. 3	Monax	Light	4	12	22.2
Fig. 3	Genco	Light	4	14	23.9
Fig. 5	Rippled	Clear	11	9	8.7

density" shall end and "medium density" begin, owing to a lack of standardization, for what one glass manufacturer would call light another would call medium and vice versa, it being merely a matter of degree with each manufacturer and depends on his point of view.

The arbitrary limits fixed by the photometric division of the Illuminating Engineering Laboratory for classifying globes used in Novalux units and luminous arcs, in reference to their density and transmission or loss, are given in Table II.

TABLE II

Designation	Per Cent Transmission	Per Cent Loss
Clear	90 or more	10 or less
Very light density	85 to 90	15 to 10
Light density	75 to 85	25 to 15
Medium density	60 to 75	40 to 25
Heavy density	50 to 60	50 to 40
Very dense	50 or less	50 or more

Experience has taught that a globe which is satisfactory for a luminous arc lamp may not be at all satisfactory when used with an incandescent lamp and vice versa.

If it is desirable to use a refractor and at the same time conceal it from view, a diffusing globe cannot be used as it would nullify the distribution of light which a refractor gives.

It has been necessary, therefore, to make globes from various types of glass in order to obtain the different effects desired.

One of the latest developments consists of globes of clear rippled glass having different finishes such as acid etching, a light flashing of opal or alabaster glass. Globes of this type will conceal the lamp and refractor and give brilliancy and snap to the light from an incandescent lamp.

Brightness, which is commonly expressed in candlepower per square inch, is an important factor in selecting the proper globe for various purposes. It should be borne in mind that with the same lamp a small globe will appear brighter than a large globe while the same amount of light may be transmitted. When lamps of low candlepower are used they should be equipped with smaller globes than where high candlepower lamps are used, otherwise the effect may be disappointing.

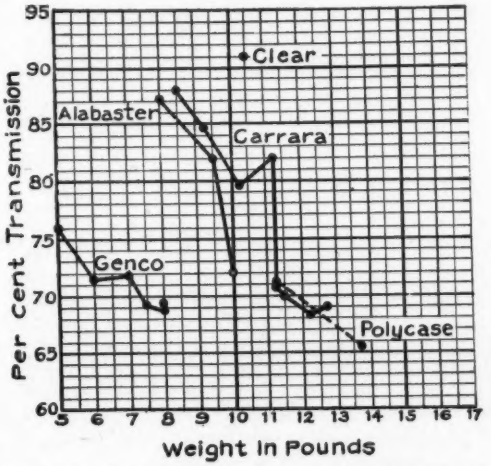
For this reason globes of the same shape have been developed in various sizes, such as those shown in Figs. 3 and 4, 5 and 6, 7 and 8, and 9 and 10. In general, it may be stated that the smaller globes should be used for lamps of 400 c-p. or less and the larger globes for 600 c-p. or more.

When a clear glass globe has its surface roughened or depolished, either by sand blasting or acid etching, it is spoken of as crystal roughed inside, crystal roughed outside, crystal roughed inside and outside, depending on whether the inner, outer, or both surfaces are roughened. These terms are usually abbreviated to C.R.I., C.R.O., C.R.I. and R.O.

If other than a clear glass globe is roughened, the term "crystal" or the letter "C" is omitted from the designation. In general, acid etching gives a smoother finish than sand-blasting, and for this reason a light acid etched finish is sometimes called "velvet finish" (V.F.) or "satin finish" (S.F.).

This treatment increases the diffusion but also increases the loss. A comparison of various kinds of glassware is given in Table I. The per cent loss given is for the glassware only, the light from the unit without the glassware being taken as 100 per cent. The efficiency of complete units with globes listed in Table I will vary from 60 to 80 per cent, depending on the type of fixture and density of glassware.

With few if any exceptions, the loss of light in a globe is proportional to the weight, or we may say the transmission of a globe is inversely proportional to its weight. This is illustrated by the curves in Fig. 15 which are prepared for



ILLUSTRATING THE EFFECT OF THE THICKNESS OF THE GLASS UPON LIGHT TRANSMISSION. THE CURVES REFER SPECIFICALLY TO THE TYPE AND SIZE OF GLOBE SHOWN IN FIG. 3.

the Fig. 3 type of globe made of different kinds of glass available at the present time. Investigations now under way indicate that the weight of genco globes may be increased to give the necessary mechanical strength for street lighting service without reducing their high transmission factor.

Ideal globes for street lighting are those which have high transmission factors with proper diffusion to obtain the results desired without sacrificing mechanical strength. While a comparison of globes on a basis of transmission efficiencies is necessary and desirable, it should be remembered that this is only one factor to be considered in the choice of a street lighting unit. In the final analysis, the elements composing a street lighting system may be considered 100 per cent efficient when the system as a whole gives 100 per cent satisfaction.

Helpful Suggestions for Glass Cutters

The following points should be considered when a stone is chattering or is not working satisfactorily:

Are the spindles properly pointed?
Are the holes too large in the blocks?
Is the pulley jumping?
Are you using an old belt that has been laced too often and improperly?
Is the belt too tight, causing the frame to vibrate?
Is the speed too high or too low? Glass cutting stones when turned to a mitre should run from 1,200 to 1,500 surface feet per minute.
Use a good stream of water on the stone. This will often eliminate acid-polishing difficulties.
Clean the sponge after turning. Wash it out thoroughly.—*From a Norton Co. Bulletin.*

The Influence of Aluminum on the Properties of Glass*

By VIOLET DIMBLEBY, B.Sc., F. W. HODKIN, B.Sc., and W. E. S. TURNER, D.Sc.

The value of alumina as a constituent of glass has been the subject of much discussion over a very long period, and although opinion in recent years has been hardening in its favor, there are many glass manufacturers who do not make use of it, there are some who question its value, and most certainly there exist but few scientific data, systematically obtained, by which the precise value of alumina can be tested.

How far back the use of alumina as a normal glass-making constituent was condemned is unknown. Nesbitt[1] states that an attempt was made by the Venetian glass-makers to use alum as a source of alkali and resulted in bad glass being produced. Certainly alumina appears to have been regarded with disfavor in the first half of the nineteenth century. Dumas[2] says that "bottle glass too rich in alumina is one of those which acids attack with the greatest facility." He believed that both the color and taste of wine were liable to be injured by aluminum salts derived from glass. Not only was alumina containing glass readily attacked by acids, according to Dumas, but he also stated that it was also a most frequent cause of devitrification.

T. J. Pelouze[3] expressed doubt, however, on the accepted conclusions that alumina was the cause of devitrification, and stated that proof of this had not actually been produced. As the result of his own experiments he believed that the devitrification was with much better reason to be ascribed to silica. Experiments made with a batch containing 250 parts by weight of sand, 100 of sodium carbonate, and 50 of calcium carbonate, to which were added amounts of alumina varying from 30 to 100 parts, showed that the glasses containing 30, 40 and 50 parts of alumina only gave definite indication of devitrification after being maintained at the softening temperature for forty-eight hours, whilst when 80 parts of alumina were present, two hundred and forty hours were required. Under the same conditions, a piece of mirror glass readily underwent devitrification. Pelouze noted that alumina could be more readily melted in a batch containing lime than in one with alkali. Even small quantities of alumina, in his view, made glass more difficult to melt.[4]

That alumina makes glass more difficult to melt is still a prevalent opinion. Pelouze thought so. It does not necessarily follow, however, that because alumina itself has a high melting point, it always raises the softening point of glass. Much depends on the composition of the glass apart from the alumina. Purdy[5] found a number of glazes which were both more fusible and less viscous when alumina was present than when it was absent. L. Appert[6] had previously drawn the conclusion that when alumina substituted silica to the extent of about 7—8 per cent. of the latter, the fusibility of the glass was somewhat augmented. The experiments of Singer[7] likewise proved that, in certain cases, the addition of small amounts of alumina might make melting easier.

Other supposed harmful effects of alumina have been cited. Thus, Henrivaux[8] considered that alumina had a tendency to convert ferric into ferrous oxide, thereby augmenting the green color, and because of this, he recommended that, for white glass, alumina should be removed as far as possible from the raw materials. A similar view was advanced by Takahashi,[9] and opposed by Orton and Bleininger.

Not only did alumina tend to produce a green color in glass, but Henrivaux also alleged that alumina made glass brittle, difficult to anneal, less workable, and likely to cause want of homogeneity.

On the other hand, both Appert[10] and Frink[11] have expressed views wholly favorable to the use of alumina. The former, as the result of analyses of satisfactory and unsatisfactory glasses, stated that alumina (1) reduces the tendency to devitrification, (2) permits the replacement, without inconvenience, and indeed, with advantage, of a portion of the soda or potash, by an equivalent quantity of lime. The glass thus obtained is harder, more durable, and more elastic, (3) is capable of substituting, without inconvenience, silica to the extent of 7—8 parts per 100. The fusibility of the glass is slightly augmented; its malleability is not sensibly diminished, (4) may cause inconvenience through the color produced, due, not to the alumina itself, but to the oxide of iron almost always accompanying it.

In some fairly pure form, such as felspar, Appert recommended the use of alumina, not only in bottles, but in other glasses also.

Frink considered that the presence of about 3 per cent of alumina promoted, rather than reduced, the homogeneity of glass produced in tank furnaces; whilst in machine-made glassware the presence of alumina rendered the glass less likely to acquire imperfections due to imperfectly surfaced molds. The readiness with which annealing could be effected was also said to be facilitated and the rate of expansion reduced.

THE OBJECT OF THE PRESENT INVESTIGATION

The only property of aluminum which may be said to have been conclusively tested is that of preventing devitrification.[12] The evidence cited may also be taken as proof that when added as alumina, in moderate amounts (not exceeding 5 per cent. in the glass), it does not necessarily make melting more difficult; the other constituents must be taken into account. The various investigations which have been made of the properties of chemical glassware also afford valuable evidence that aluminum bestows durability on glass and resistance to corrosion by water, acids, and alkalis.[13]

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*J. Soc. Gl. Tech., 1921, 17, 107-115.

[1] "Glass," 1878, p. 94.

[2] *Traité de Chimie appliquée aux Arts*, 1830, 2, 568.

[3] *Ann. Chim. Phys.*, 1867, (4), 10, 184; *Compt. rend.*, 1869, 64, 53.

[4] *Compt. rend.*, 1865, 60, 935; *Ann. Chim. Phys.*, 1865, 5, 265.

[5] *Trans. Amer. Cer. Soc.*, 1903, 5, 136.

[6] *Compt. rend.*, 1896, 122, 672.

[7] *Ker. Rundschau*, 1915, 23, 65; 1917, 25, 142. F. Springer, *ibid.*, 1915, 23, 272.

[8] *J. Pharm. Chim.*, 1889, (5), 19, 446.

[9] *Trans. Amer. Cer. Soc.*, 1911, 13, 256.

[10] *Loc. cit.*

[11] *Trans. Amer. Cer. Soc.*, 1909, 11, 99.

[12] See also Hovestadt: "Jena Glass," 1902, p. 21. W. F. J. Wood, *Trans. Soc. Gl. Tech.*, 1918, 2, 79.

[13] Cauwood, English, and Turner. *Trans. Soc. Gl. Tech.*, 1917, 1, 153. Cauwood and Turner, *ibid.*, *Trans.*, 1918, 2, 219.

In regard to other properties, the various expressions of opinion made have not been supported by data, and in the absence of these unfruitful discussion must still continue. It is far more profitable to spend a few months in experimental investigation than years in controversy in which no more than opinion is advanced.

Accordingly, these papers set out the results of experiments on certain properties of glass containing aluminum. The present paper concerns mainly the preparation of working of such glasses. One set were the simple sodium—aluminum trisilicates, based on the trisilicate formula, $6SiO_2xNa_2O,yAl_2O_3$ where $x + y = 2$; the other, sodium-calcium aluminum silicates of similar type, but in which calcium was partly substituted by aluminum.

I.—The Sodium-Aluminum Trisilicate Glasses

The molecular proportions of the constituent oxides and the batch compositions from which the glasses were prepared are given in Table I.

Table I

	Approx. Molecular Ratios.			Batch Composition. Per 1,000 Parts Sand.		
Glass No.	SiO_2	Na_2O	Al_2O_3	Soda-ash	Alumina (hydrated)	Alumina (calcined)
441A	6	1.9	0.1	589	43.5	...
442	6	1.8	0.2	558	87	...
443D	6	1.7	0.3	528	130	...
444B	6	1.6	0.4	497	173	...
445A	6	1.5	0.5	466	217	...
445D	6	1.5	0.5	466	...	142
446	6	1.4	0.6	435	260	...
446C	6	1.4	0.6	435	...	170

The sand used was Fontainebleau, and the batch quantities stated are for quite dry materials (actually, soda-ash with 5 per cent. moisture was used).

The melting was carried out in 28 lb. or 56 lb. covered pots and three charges of batch at intervals of one and a half hours were made.

Glasses 441, 442 and 443D all melted readily and became fine easily. No. 441A, it was found, could be melted satisfactorily at 1300—1325°, but the temperature actually used was 1375°, as also for 442. No. 443D was melted at 1400°.

A marked change in melting rate occurred between 443D and 444B. Not only was the required melting temperature higher, namely, 1400—1425°, but a boil was present in the glass for the first eight hours and remained on the surface for a further six, although on skimming the surface the glass below was found to be quite plain.

Glass No. 445A developed more boil than 444B. A foam-like mass, about 3 inches thick, after eight hours, was found on the surface and became solid, although the temperature of melting was 1400—1425°. Similar phenomena attended the melting of No. 446. For this reason it was decided to try the introduction of calcined instead of hydrated alumina. Small scale experiments at once showed that practically plain glasses containing 0.5 and 0.6 molecule of Al_2O_3 were obtainable with the calcined alumina after three hours at 1400°. It was not possible satisfactorily to melt a glass containing 0.7 molecule of Al_2O_3, and this is the reason why the list of glasses in Table I ends at glass 446.

On the large scale, Nos. 445D and 446C gave no difficulty when calcined alumina was used, although boil persisted for twelve hours in the former, whilst No. 446C was not obtainable quite bubble free.

Table II

Percentages Composition of the Finished Glasses

Glass No.	SiO_2	Al_2O_3	Na_2O	CaO	MgO	Fe_2O_3	Total	Percentage Loss on Ignition
441A	74.30	2.72	22.68	0.08	trace	0.07	99.85	2.56
442	73.30	4.25	22.20	0.02	"	0.10	99.87	2.61
443D	72.05	6.85	20.62	0.12	"	0.08	99.72	1.80
444B	72.19	8.96	18.79	0.08	"	0.08	100.10	....
445D	72.27	10.71	16.61	0.21	"	0.07	99.87	0.72
446C	71.56	12.69	15.28	0.21	"	0.10	99.84	0.39

The analyses were carried out on samples of the glasses dried at 105°. The figures under the heading of loss on ignition mainly represent the amount of moisture absorbed by the finely divided powder during grinding and they indicate the relative hygroscopic values and therefore also the approximate order of durability. The conditions of grinding were roughly, not precisely, the same.

Working Properties of the Sodium-Aluminum Trisilicate Glasses

I.—In the Mass

Glass 441A was worked easily when gathered from the pot between 1300° and 1250° and was drawn with ease into rod and tubing. The rate of increase of viscosity was very slow. On the other hand, the surface of the glass appeared to become rapidly chilled on the iron marver, so that, in the contraction markings, bubbles were readily trapped if a second gathering of glass was made. Indeed, it was found desirable not to employ the marver when a further gathering was to be made. This applied also to glass 442.

The viscosity of glass 442, when gathered from the pot at 1300—1250°, was slightly greater than that of 441A, and as it also increased rather faster, tube drawing was easier than with 441A.

The best gathering temperature for glass 443D was 1300°, and the glass then was worked easily. Unlike the two preceding glasses, it cooled off much less rapidly, and in this respect resembled the behavior of the magnesium glasses.[14] The increase of viscosity above 442 was much greater than that observed between 441A and 442. Between 1250° and 1200° the glass appeared comparatively hard. No difficulty was observed in marvering the glass, but quick drawing was necessary in making tubing.

At 1325°, glass 444B could be worked very satisfactorily. Cooling off was slow, as with glass 443D and the similar magnesium glasses, but the viscosity rapidly increased. While still red hot, the glass was quite hard, but still elastic and capable of being drawn out to a limited extent.

Glass 445D, gathered at 1275°, was too viscous to be shaped on the marver, but could be drawn into rod. The best working temperature lay between 1375° and 1325°. Even when gathered at 1400°, slabs could not be made by pouring owing to rapid hardening.

At 1400°, it was almost impossible to gather glass 446C

[14]Davidson, Hodkin, and Turner, *Trans. Soc. Glass Tech.*, 1919, 3, 275.

properly, and it remained in distinct bands round the end of the gathering iron. Immediately it was removed from the pot the glass appeared to lose its mobility, although in spite of this, rod, and with great care, a little tubing, could still be drawn at 1375°. At 1325° the metal was unworkable in any fashion.

2.—Lampworking Properties. Devitrification

There were two objects in view in testing the sodium-aluminum silicate glasses in the lamp, namely, to ascertain the general effect of the aluminum, first on the ease of working, and secondly on the tendency to devitrification.

It has already been shown that the sodium-calcium and the sodium-magnesium glasses in themselves are unsuitable for lamp-working purposes. In the case of the sodium trisilicate glasses and the calcium glasses, varying from a molecular composition $6SiO_2,2Na_2O$ to $6SiO_2,Na_2O,CaO$, devitrification readily occurs, although much less readily as the calcium content increases. Similar results were found with the corresponding magnesium glasses.

With aluminum replacing calcium, magnesium, or sodium, the difference was striking. Glass 441A, although containing but 2.72 per cent of Al_2O_3, resembled a lead glass in its general working properties, could readily be blown into large bulbs, and showed no sign of devitrification. Glasses 442 and 443D were less soft, although 443D was still slightly softer than most commercial non-lead glasses. They devitrified only under excessive working.

Glass 444B, with 9.66 per cent of alumina, was somewhat similar in working properties to ordinary commercial lampworking tubing. Long and excessive working was necessary to induce devitrification. Glass 445D was distinctly harder, while 446C was very hard and the ordinary gas blowpipe flame scarcely hot enough for its working.

In general, the bloom so frequently met with in lampworking glass became less and less noticeable as the aluminum content increased, and devitrification was increasingly difficult to bring about.

Obviously, these tests furnish proof of the value of alumina as a constituent in glass for lampworking and, in particular, of its power of preventing devitrification.

II.—The Sodium-Calcium-Aluminum Silicate Glasses

As glasses containing sodium and aluminum silicates only are unknown as yet to commerce, it was considered desirable to make some test of the effect of alumina when added to an ordinary commercial glass. As the commonest commercial glasses contain calcium, one of this type, having the molecular formula $6SiO_2,1.1Na_2O,0.9CaO$, was selected for experiment. In this glass, the CaO was substituted 0.1 molecule by 0.1 molecule of Al_2O_3. Three such glasses were prepared, as stated in Table II.

Table III

Glass	Molecular Ratios.				Batch Composition Per 1,000 Parts of Sand.		
No.	SiO_2	Na_2O	CaO	Al_2O_3	Soda-ash	Limespar	Hyd. Alumina
458	6	1.1	0.6	0.3	341	167	131
459	6	1.1	0.7	0.2	341	197	87
460	6	1.1	0.8	0.1	341	222	43.5

Of the three glasses, No. 460 melted and became plain most easily at the temperature of 1375—1400°. At this temperature it could be gathered easily, and although the viscosity increased rapidly it could be marvered and drawn into tubing without difficulty.

No. 459 required twenty hours at 1375—1400° in order to obtain it plain. At 1375° it was almost hard in the pot and was not easy to gather or marver. Nevertheless, it could be drawn into lengths with great ease.

A temperature of 1375—1400°, although sufficient for melting, was insufficient for fining glass 458. After twelve hours it was still full of bubbles; there was little improvement after a further two hours at 1400°, but an additional four hours at 1425° brought the glass to the nearly plain condition. This glass was also very viscous at 1375—1400°, and gave very great difficulty in forming the parison, but even when apparently hard could be drawn out quite readily.

Table IV

Percentage Composition of the Glasses

Class No.	SiO_2	Al_2O_3	CaO	MgO	Na_2O	Fe_2O_3
460	74.13	2.67	9.74	0.09	13.54	0.09
459	74.25	5.23	7.91	0.06	12.72	0.07
458	73.98	7.10	7.10	trace	11.66	0.10

Lampworking Properties and Devitrification

For lampworking purposes, glass No. 458, containing 7.1 per cent of alumina and 7.1 per cent of lime, was, although a little hard, very similar in working properties to several types of commercial tubing. Glasses 459 and 460 were harder, showed bloom more readily than 458, but became devitrified after bulbs blown on them had been twice reheated and blown. With 458 a bulb was blown and re-blown thirty times without devitrification, even on strong heating. A crinkly appearance was, however, developed, but in this respect also 459 and 460 were much worse.

Summary and General Conclusions

1. Two series of glasses have been prepared for the purpose of testing the effect of aluminum on the properties of glass, the first series being the sodium-aluminum trisilicates lying between the compositions $6SiO_2,2Na_2O$ and $6SiO_2,1.4Na_2O,0.6Al_2O_3$, the second being the sodium-calcium-aluminum trisilicates.

2. At temperatures up to 1400—1425° it is not possible in the first series to melt and plain a glass containing more than about 12.7 per cent of alumina. Under the same conditions of temperature, a glass containing 73.98 per cent silica, 11.6 sodium oxide, 7.1 calcium oxide, and 7.1 alumina can only just be obtained clear and bubble free.

3. In the sodium-aluminum trisilicate series, viscosity undergoes rapid increase with increase of alumina, especially after the introduction of about 7 per cent of alumina. Such glasses increase notably in toughness with aluminum content. A curious phenomenon is noticeable in the working of the glasses, especially with increase in the aluminum percentage. The parison, especially if marvered, acquired a hard skin, and a distinct effort was necessary to break it during the process of drawing tube. When this was done, the glass as a whole could readily be drawn.

4. The conductivity for heat, as indicated by the rate of cooling of masses of gathered glass, appears to diminish as the content of aluminum increases.

5. Aluminum in glass is very favorable to easy manipulation in lampworking.

6. Further abundant proof is given of the value of aluminum in preventing devitrification occurring in glass. This is evident in both series of glasses tested. The ready devitrification of the glass $6SiO_2,1.1Na_2O,0.9CaO$ is easily prevented by partly replacing calcium by a small percentage of aluminum.

7. A moderately hard glass of the type $6SiO_2,1.1Na_2O$, $0.9CaO$ is made more readily fusible by small amounts of alumina. Glass 460 was found by the investigators to melt and to fine much easier than the corresponding glass without alumina.

In order that the account given here may be more complete, it may be stated that the evidence produced in succeeding papers will demonstrate that aluminum, over the range of composition tested, reduces the annealing temperature of glass as compared with calcium and magnesium, and notably diminishes the rate of thermal expansion and the density.

The Effect of Aluminum on the Annealing Temperature of Glass*

By S. ENGLISH, M.Sc., and W. E. S. TURNER, D.Sc.

As indicated in another communication† the only two references known to us concerning the effect of aluminum on annealing temperature are contradictory in character. Henrivaux's opinion was that glasses containing this element were difficult to anneal. Frink, on the other hand, expressed the opinion, doubtless based on observations in practice, that annealing was rendered easier when alumina was a significant constituent of the batch mixture.

The two sets of glasses, namely, the sodium-aluminum trisilicates and the sodium-calcium-aluminum trisilicates described in the preceding paper, make it possible to carry out definite tests so as to afford some proof of the influence of aluminum.

Determinations of the annealing temperature were carried out, as in previous investigations, by the optical method. The results are set out in the two following tables, I and II, and, in the case of the sodium-aluminum-silicate glasses, also in diagrammatic form so as to admit of comparison with other trisilicate glasses previously studied.

TABLE I
SODIUM-ALUMINUM TRISILICATE GLASSES

Glass No.	Al_2O_3 Per Cent	Annealing Temperature
1	....	490°
441	2.72	491
442	4.25	492
443	6.85	501
444*b*	8.96	510
445*d*	10.71	522
446*c*	12.68	535

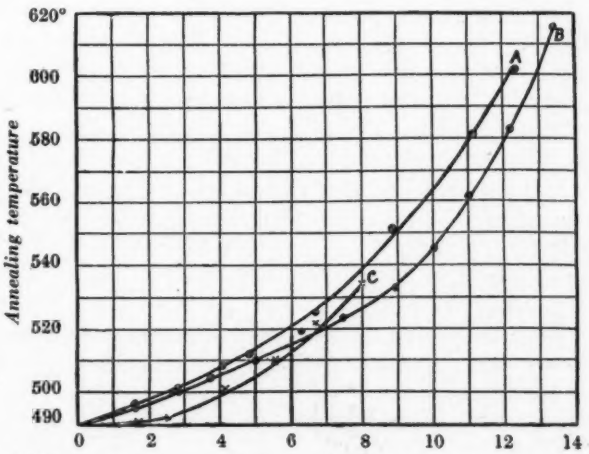
TABLE II
SODIUM-CALCIUM TRISILICATE GLASSES

Glass No.	Al_2O_3 Per Cent	CaO (and MgO) Per Cent	Annealing Temperature
10	0.44	10.91	581°
460	2.67	9.83	562
459	5.23	7.97	560
458	7.10	7.10	561

Glass No. 1 in Table I was intended to correspond in composition with $2Na_2O,6SiO_2$. The small amount of alumina present is that taken up during its preparation in fireclay vessels. The alumina also in Glass No. 10 (Table II) is derived in a similar manner, its intended composition being approximately $1.1Na_2O,0.9CaO,6SiO_2$.

Considering first the results stated in Table I, it will be noted that substitution of sodium by aluminum has scarcely any effect in the early stages, that is, up to a substitution to the extent of 0.2 molecule of the base. After that stage the annealing temperature rises more rapidly.

If we compare the effect of calcium, magnesium, and aluminum in glasses in which the oxides of these elements replace one another molecularly, then, as will be seen from the diagram (Fig. 1), the annealing temperature of aluminum



Molecules per cent of CaO (*A*), MgO (*B*), *or* Al_2O_3 (*C*).

FIG. 1.

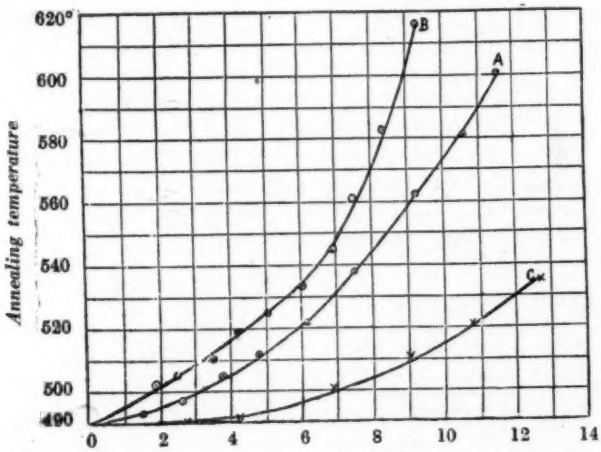
glasses is below that of calcium or magnesium glasses up to nearly 7 molecules per cent, and is still below that of the calcium glasses at 8 molecules per cent. From the slope of the curves, it is quite likely that below 9 molecules per cent the annealing temperature of the aluminum-containing glass would exceed that of the calcium also; but as it would be very difficult to melt a glass with such a high proportion of aluminum, it is reasonable to conclude that, *for all practicable working purposes,* the sodium-aluminum trisilicate glasses are more readily annealed than the corresponding calcium or magnesium glasses.

If now, instead of the molecular comparison, we compare

*J. Soc. Gl. Tech., 1921, 17, 115-118.
†Trans. Soc. Gl. Tech., 107.

the effect of each 1 per cent addition by weight of the oxide, CaO, MgO, or Al_2O_3, it will readily be seen that the effect of aluminum in raising the annealing temperature is least of all. This readily follows from a study of the curves given above and a recollection of the respective molecular weights of the three oxides. The actual curves are given in Fig. 2.

The comparison of the calcium and aluminum glasses is carried a stage further in the glasses described in Table II. It is seen there that the first substitution of 0.1 molecule of CaO by $0.1Al_2O_3$ brings about a diminution of the annealing temperature by nearly 19°. Indeed, the annealing temperature of the glass 460 (approximately $1.1Na_2O,0.8CaO,0.1Al_2O_3,6SiO_2$) is the same as glass 9* (approximately $1.2Na_2O,0.8CaO,6SiO_2$). In the two other glasses, in which 0.2 and 0.3 molecule of Al_2O_3 are respectively substituted, the annealing temperature is practically identical with glass 460; in other words, over this particular portion of the range of composition, calcium and aluminum have practically the same effect on the annealing temperature.



Percentage by weight of CaO (*A*), MgO (*B*), *or* Al_2O_3 (*C*).

FIG. 2

It has previously been pointed out by us that the variation of annealing temperature with composition appears to follow no simple law, and the two sets of results recorded above afford further illustration of this fact. If, however, we bear in mind that the annealing temperature is really the temperature at which softening occurs to a definite extent, we shall not be surprised at the lack of distinct regularity. The softening temperature, like the melting point of the batch mixture, does not necessarily increase or diminish regularly with the regular variation of some specific constituent. We found, actually, that in melting rate and viscosity of the glasses there was a somewhat bigger difference between glasses 442 and 443 than between glasses 441 and 442, while a still more marked change occurred between glasses 443 and 444.

Our conclusion, therefore, after a study of the effect on the annealing temperature, is that, as compared with calcium and magnesium, aluminum generally brings about a reduction; in other words, annealing is rendered easier by the presence of aluminum. This is not without exception, however. In two glasses examined, containing both calcium and aluminum, the substitution of the former by the latter element was without effect on the annealing temperature. So far, we have found no case where the substitution of calcium by aluminum raises the annealing temperature.

Trans. Soc. Gl. Tech., 1919, 3, 125.

A New Vacuum Bottle

A new German vacuum bottle, so constructed as to eliminate the necessity of an outer covering or casing, is described in a recent issue of *Schnurpfeil's Review*, as follows:

"As is well known, the vacuum flasks consist of two glass bottles smelted together at the neck and which, in order to isolate or preserve the warmth are separated from one another by a vacuum. To protect it from oscillation or concussion in the handling of the flask the inner body is provided with an intermediate central piece of asbestos or other material. To protect the glass flasks a padding of corrugated cardboard is used and over this comes the metal cover—usually of tin. The more expensive flasks have an outer case of nickel or brass. The upper part of the outer case is generally of aluminum with a worm upon which the drinking cup is screwed.

"The new flask, which is named 'Hermetos,' consists also of two glass bottles, but as the result of a special process these possess a considerably greater power of resistance so that there is no need of an outer case. The outer one of the two bottles is specially thick and is provided at the bottom with a ring pad over which an aluminum cap is fitted. The drinking cup fits directly on the glass neck. This is accomplished by means of two protuberances or bosses on the glass of the neck—produced by mechanical means on the bottles. The drinking cup has two corresponding bulges which fit tightly over the bosses on the neck.

"The advantage of the new flask lies in the extreme toughness of the glass—no metal outer cover being required. The Hermetos flask also possesses a great hygienic advantage: it can be cleansed with extreme simplicity and thoroughness. The outside of the Hermetos flask can be cleaned by merely wiping it with a cloth, and in the kitchen it can be treated exactly as any other glass utensil. It consists almost entirely of glass. No screwing on of the lid is necessary. The liquid which in ordinary flasks collects inside the outer cover through overflowing at the moment of filling, is apt to spoil the drink as it mingles with the same when the contents are poured into the drinking cup. The Hermetos flask is quite free from this defect. The flasks are also silvered inside which gives them a very presentable appearance."

Proposed Specifications for Tableware

Recently the Bureau of Standards has investigated the need for specifications in connection with tableware of the sort used by hotels and restaurants. It has been found that there is a lack of uniformity among the specifications used and in many cases no specifications of any sort are employed. After corresponding with a great many makers and users of this class of material, it appears that uniform specifications in this field would be of great benefit and would result in considerable economies. A preliminary survey of the situation is being made and available specifications studied.

The Electrical Properties of Glass*

By J. R. CLARKE, M.Sc.†

The properties which have to be considered in selecting an insulating material have been classified by Recklinghausen[1] as follows:—

(1) Electrical Properties.
  (a) The Insulation Resistance.
  (b) The Dielectric Constant or Specific Inductive Capacity.
  (c) The Dielectric Strength.
(2) Mechanical Properties.
(3) Chemical Properties, such as the resistance to attack by moisture, etc.

The mechanical and chemical properties of glass have been the subject of much research, but the electrical properties have received less attention. There is no relation known between the three electrical properties mentioned, though they must be connected in some way. Their relative importance depends on the use to which the glass will be put. For the manufacture of sparking plugs (recently started in America) the first is most important; for high voltage insulation, the first and third have chiefly to be considered; for use in condensers, the second and third are the properties mainly concerned. In this article the properties will be considered in the order named and the published work on each will be summarized.

Insulation Resistance

The transmission of electricity by glass occurs in two ways; by leakage over the surface and by conduction through the mass. The former method was first investigated by Warburg and Ihmoi[2] who showed that it is due to the formation of a conducting film on the surface of the glass. This was confirmed by Kohlrausch[3] who found that glasses which are chemically bad also insulate badly; the conducting film is quickly formed on the surface of such glasses by the action of the water vapor and acids present in the atmosphere. Further work by Trouton and Searle[4] points to the same conclusion. Curtis[5] has carried out extensive investigations into the effect of humidity, elevation of temperature and exposure to light on the surface leakage of dielectrics. He has found that the decrease of surface resistance of glass with increasing humidity is specially marked between relative humidities of 30 and 70 per cent., being very small outside this range. The leakage was only slightly affected by rise of temperature, and not affected by light. In the latter property glass differs greatly from other insulators, such as hard rubber, which exhibit a large decrease in surface resistance when exposed to light.

That electricity is transmitted through glass, was first remarked by Siemens in 1861. He observed that the glass of a Leyden jar was heated on charge and discharge. Further investigation by Warburg[6] showed that glass conducts electrolytically. He passed a current through a soda-lime silicate glass, at 300°C, between mercury electrodes, and found that a badly conducting layer, the thickness of which depended on the applied E.M.F., was formed at the anode whilst metallic sodium was produced at the cathode. When sodium amalgam was used as the anode instead of mercury the badly conducting layer was not formed and the glass remained unaltered. Experiments by Tegetmeier[7] and Le Blanc and Kerschbaum[8] have confirmed this, those of the latter showing that when the anode layer was heated oxygen was evolved to an amount corresponding to the weight of the sodium deposited at the cathode. Heydweiller and Kupfermann,[9] working at temperatures of 250° to 450°C, observed that various metals, when used as electrodes, migrate into the glass and assume the colloidal state. Schulze[10] studied the electrolysis of glass, at 350°C, in great detail. He found that the only substances which do not migrate into glass are graphite and platinum. The resistance of the glass was diminished by the migration into it of lithium and silver; increased by K, Tl, Cu and Fe; and greatly increased by Cd, Hg, Pb, Bi and Sn. Speranski[11] used electrodes of sulphuric acid and found that a soda glass became opaque, the electrical conductivity falling at first and then increasing rapidly. This increase is rather surprising, and may be due to the effect of the acid electrode. It is noteworthy that he did not obtain a similar result with chemically resistant glasses. It might have been thought that as glass conducts electrolytically, it would have been very suitable for use in electrolytic rectifiers. The badly conducting layers at the electrodes in the case of glass, however, are solids in which ordinary electrolytic processes are taking place, whereas in rectifiers, they are gaseous.

The formation of these layers has made difficult the measurement of the volume resistivity. This may account for the small amount of data concerning the variation of the electrical conductivity with composition. Gray & Dobbie[12] examined twelve glasses in 1898, having previously observed that the specific resistance increases with the percentage of lead oxide in the glass. Their results indicate that a glass which approaches in composition to a definite chemical compound has a high resistance; for example, a barium boro-silicate had a resistivity of more than 59×10^{13} ohms at 140°C. The presence of potash in the glass was found to conduce to a high resistance, but soda has a reverse effect. They also observed that glass which is well annealed is a much better insulator than that which is in a state of strain. This result is important in view of the little attention which has been paid to the annealing of glass insulators. Ambronn[13] measured the resistance of twelve soda-lime silicate glasses at various temperatures. His results confirm Gray & Dobbie's view that a glass which nearly approaches to a chemical compound is a good insulator. An increase in the percentage of lime present

* *Beama*, 1921, 8, 235-238.
† Assistant Lecturer in Physics, The University of Sheffield.
[1] Amer. Electro-Chem. Soc., 1903.
[2] Ann. d. Phys. u. Chem., 1896, 27, 481.
[3] Ber. d. Deutsch. Chem. Ges., 1893, 26, 3002.
[4] Phil. Mag., 1906, 12, 336.
[5] Bull. Bureau Standards, 1914-15, 11, 359.
[6] Ann. d. Physik, 1884, 21, 622. This paper also contains a bibliography of work previously published on the electrical properties of glass.
[7] Ann. d. Physik, 1890, 41, 180.
[8] Zeitschr. f. Phys. Chem., 1910, 72, 468.
[9] Ann. d. Physik, 1910, 32, 739.
[10] Ann. d. Physik, 1912, 37, 435.
[11] Russian Physico-Chem. Soc., 1915, 47, 52.
[12] Proc. Roy. Soc., 1898, 63, 38; 1900, 67, 197.
[13] Phys. Zeitschr., 1913, 14, 112; 1918, 19, 401. Ann. d. Physik, 1919, 58, 139.

increased the resistance of the glass. Phillips[14] has made a special conducting glass which is of use for electroscope fibres; its specific resistance is only 5×10^8 ohms at 20°C.

Measurements of the variation of the resistance of glass with temperature are also attended by the difficulty of the polarization of the electrodes, this being accentuated at high temperatures. Dunoyer,[15] applying a voltage such that the gradient was 0.5 volts per cm. found a slight diminution of the conductivity from 16° to 150°C, which he attributed to the improved drying of the surface at higher temperatures. The conductivity increased rapidly in the range 180° to 220°C. Dietrich[16] found that the resistance decreased exponentially with rise of temperature—a result confirmed by Ambronn's experiments (*loc. cit.*) Campbell[17] measured the resistance of a lime-soda glass at 18°C. and 145°C. and obtained a diminution from 5×10^{13} to 10×10^9 ohms per cm. cube. The resistivity of Jena combustion glass at 750°C. was about 2×10^6 ohms per cm. cube as compared with 2×10^{16} at 18°C. Curtis (*loc. cit.*) also observed an exponential decrease of resistivity with increase in temperature, and an examination of his results confirms Kohlrausch's dictum that chemically good glasses are good insulators. Investigating the effect of other conditions on the volume resistivity, Curtis found that it decreased very slightly with increasing humidity and that, in general, glass shows a decrease of resistance as the voltage gradient increases, opal glass being exceptional in this respect. Bairsto[18] has observed that the conductivity of crown glass increases with the frequency of the voltage applied to a maximum of 3 by 10^8 mhos per cm. cube, at a frequency of 5 by 10^5 cycles per second and then slowly decreases. The D. C. conductivity of the glass he examined was 12 by 10^{12} mhos per cm. cube.

Dielectric Constant

The high specific inductive capacity of glass, when compared with dielectrics such as bakelite, makes it specially suitable for use in condensers. Winkelmann[19] found that the dielectric constant varies slightly with the composition of the glass, but Gray & Dobbie (*loc. cit.*) obtained a larger variation though they do not ascribe an increase to any particular constituent. A survey of their results, however, indicates that a high silica or soda content tends to produce a low S.I.C. This accords with the relation between the refractive index and the S.I.C. ($n = \sqrt{k}$.) deduced from the electromagnetic theory of light. It is also of interest to note that a combination of Gladstone & Dale's Law, connecting the refractive index and density ($n - 1 = d \times$ constant) and $n = \sqrt{k}$, leads to a formula similar to that obtained experimentally by Thornton,[20] namely, $k\text{-}k_1 = b\ (d\text{—}d)^2$ where k_1, b, and d_1 are constants. Thus, at present, for information concerning the variation of the dielectric constant of glass with its composition we have to refer to the variation with composition of its refractive index or density.

Investigations on the accuracy of the formula $n = \sqrt{k}$ have led to the measurement of the variation of the S.I.C. with the frequency of the applied voltage. Broca and Turchini[21] state that to use Leyden jars for high frequency currents the capacity determined at low frequency must be multiplied by a correction factor. For frequencies of the order of 10^6 the capacity measured by D.C. charges of 0.1 second duration, must be multiplied by 0.5, if measured by ordinary A.C. the factor is 0.7. This indicates a large decrease of S.I.C. with increasing frequency, a result which agrees with the observations of Winkelman,[22] Thomson,[23] Löwe[24] and others. On the contrary, Pollock and Vonwiller,[25] Stockley,[26] and Bairsto (*loc. cit.*) record only a very slight variation. On the whole, it appears that there is an anomalous dispersion as remarked by Winkelmann.

Measurements of K. with D.C. give results which vary greatly with the time of charge. Curie and Compan[27] obtained results for a specimen of crown glass which showed a variation from 7.89 to 11.25 as the time of charge was increased from 0.05 to 10 seconds. This increase is confirmed by Malclès[28] and is attributable to the absorption of electricity by the glass. The dielectric constant at low temperature was measured by Curie and Compan (*loc. cit.*) and they found a decrease with temperature represented by the formula $K = K^0 + AT$, T being the absolute temperature. It is of interest to note that, at temperatures below -75°C., K was independent of the time of charge. Stockley (*loc. cit.*) found a four per cent. increase in K as the temperature rose from 20° to 70°C.

The variation of the S.I.C. with the strain to which the glass is subjected has been investigated by Wullner and Wien,[29] and Adams and Heaps[30] among others. It appears probable that there is an alteration in K corresponding to the changes in refractive index produced by the strain, but it is only very slight. Akin to this is the question of the elongation of glass tubes when charged. More[31] concluded that the elongation was doubtful, but Bouchet[32] has shown that an electric charge does produce a small deformation.

Dielectric Strength

In spite of the large number of tests which must have been made in electrical factories on the dielectric strength of glass very little work has been published concerning this property. Walter[33] records that a specimen of window-glass had a dielectric strength of about 9,000 volts per mm., whilst lead glass broke down at 5,500 and alabaster glass withstood 11,000 volts per mm. Steens[34] found that a sheet of "ordinary" glass, 0.3 mm. thick, resisted 25 K. V. when the voltage was continuous, but was pierced by a condenser discharge of this voltage. Moody[35] states that glass has no time factor, *i.e.*, the voltage required to pierce a sheet of glass is independent of the time for which it is applied. The writer has observed a small time factor when testing glass under oil. A

[14] Proc. Roy. Soc., Edin., 1907-8, 28, 627.
[15] Comptes Rendus, 1909, 149, 1120.
[16] Phys. Zeitschr., 1910, 11, 187.
[17] Proc. Phys. Soc., 1913, 25, 336.
[18] Proc. Roy. Soc., 1920, 96, 363.
[19] Ann. d. Physik, 1889, 38, 161.
[20] Proc. Roy. Soc., 1909, 82, 422.
[21] Comptes Rendus, 1905, 140, 780.
[22] Ann. d. Physik, 1889, 38, 168.
[23] Pro. Roy. Soc., 1889, 46, 292.
[24] Ann. d. Physik, 1898, 66, 390.
[25] Phil. Mag., 1902, 3, 586.
[26] Schweiz. Elektrotechn. Zeitschr., 1909, 6, 389.
[27] Comptes Rendus, 1902, 134, 1295.
[28] Comptes Rendus, 1907, 144, 264.
[29] Ann. d. Physik, 1903, 11, 619.
[30] Phil. Mag., 1912, 24, 507.
[31] Phil. Mag., 1901, 2, 527.
[32] Ann. de Physique, 1919, 12, 303.
[33] Elektrotechn. Zeitschr., 1903, 796.
[34] Elect. Review, 1904.
[35] Trans. A.I.E.E., 1903.

sheet of glass 3 mm. thick broke down at 35 K. V. in fifty seconds, and at 33 KV. when applied for six minutes. It was also found that glass behaves similarly to mica in that its dielectric strength in air is greater than if the tests are carried out under oil. The glass referred to withstood 48 KV. in air, a higher voltage being unobtainable because of flash over. A dielectric strength in oil of about 10 KV. per mm. is apparently about the average for window-glass with A.C. of ordinary frequencies. For impulse frequencies (of the order of 10^6 cycles per second) this will be considerably decreased as with other dielectrics.

Other Properties

In addition to the three outstanding electrical properties of glass, mention must be made of the variation of Kerr's constant in different glasses. Tauern[36] defines this as the difference of the refractive indices of rays of light, polarized parallel and perpendicular to the direction of the electric field, which is produced by unit field. He found that this constant increases with the amount of lead in the glass.

The transparency of glass to X-rays may also be considered an electrical property. Hovestadt[37] records a number of experiments on the effect on the absorption of the introduction of various oxides into the glass, but the effect seems to be mainly one of density. It may be remarked, however, that glasses which are specially transparent to ultraviolet light, such as Jena Uviol glass and Phillips' glass are also very transparent to X-rays.

Conclusion

In conclusion we may discuss which glasses will be suitable for two or three electrical purposes. For line insulators, in addition to the electrical and mechanical properties, we have also to consider the cost. This necessitates the manufacture from cheap materials in a tank furnace, thus excluding the use of lead. The surface leakage must be low, and hence the resistance to chemical attack fairly high; the S.I.C. should be low, to reduce flash-over, and the dielectric strength fairly high to prevent penetration. Further, the co-efficient of expansion must be small[38] and the glass should be well annealed. All these conditions indicate a glass of high silica content. The alkali would probably be potash, for though this makes for a high S.I.C., it also conduces to a high resistance. On the whole a potash-lime silicate with as high a silica content as possible, would be best, so far as can be ascertained from data at present available.

For glass for condensers, the dielectric constant and dielectric strength must be high and the surface leakage low. For low voltages the value of the dielectric strength is not so important and a lead-potash silicate will serve. If the condenser is to be used for high voltages, Walter's experiments indicate that lead should be excluded and probably a barium-boro silicate, similar to that used by Gray & Dobbie, would be best.

Glass for X-ray tubes must be light and have a high surface resistivity. Moreover it must be easily workable in the blow pipe flame. A potash-lime glass with fairly high silica content again seems to be indicated.

As more knowledge is obtained concerning the variation of electrical properties with composition, these conclusions will probably have to be revised. Research work is being carried out, so that ultimately the electrical manufacturer may be provided with the ideal glass for any particular purposes.

[36] Ann. d. Physik, 1910, 32, 1064.
[37] "Jena Glass," 1901. English translation.
[38] Meyer (Elektrotechn. Zeitschr, 1919) records a case of sixty glass insulators cracking suddenly in a cold shower on a hot day. This would not have taken place had the glass had a low co-efficient of expansion and been well annealed.

Manufacture and Use of Glass Bricks in France*

(*Translated for* THE GLASS INDUSTRY)

Glass bricks are being made in France by the Garchey process, a patented procedure, by the Garchey Glass Brick Company (Societe Anonyme de Pierre de Verre Garchey). The company was founded in 1900 with a capital of $115,800, prospered very well and has developed into one of the most prominent concerns in this line of glass manufacturing. Factories at Toulouse, Lyon, Creil and Demi-Lune are almost entirely devoted to the making of glass bricks.

The raw material of these bricks is broken bottles and broken window glass. For the higher grades, a glass made of 5 parts of sand, 4 parts of lime and 1 part of alkali is used. The melt is poured in water and is thus broken up. By heating the raw material to the melting point it is changed to a plastic mass, which can be pressed into any shape desired by means of hydraulic presses. The bricks are then put through a lehr. Garchey bricks are used for a number of purposes. The better grade of bricks are used to build the walls and floors of bathrooms, operating rooms, and waiting rooms. Since the brick has all the good qualities of glass, and is not attacked by chemicals, it is used extensively in factories and laboratories.

The use of these bricks increased when it became possible to make architectural designs on them. Glass bricks are not used like common bricks in the building of walls, but experiments are being made with this object in view. By adding powdered brick to the batch it has been found possible to make a product resembling common brick which, however, is as yet higher in price. These bricks are useful for the building of walls below the surface of the ground, as they completely exclude water. Glass bricks undoubtedly will have a great future and will find a wide application.

*Diamant, 43, p. 299 (June, 1921).

A Glass Factory in the Dutch East Indies†

The glass works which it is proposed to build at Medan will manufacture especially rubber cups, that is to say, receptacles used in the collecting of crude rubber.

Statistics show that the island of Sumatra has imported more than ten million rubber cups every year. Its needs are therefore more than sufficient to give work to a factory of some importance.

The daily output will amount to 25,000. The capital is 750,000 florins ($300,000) and it is estimated that the company can earn an annual dividend of 40% by selling the rubber cups at the price of 75 florins ($30.00) per thousand.

†Le Verre, No. 6, p. 127 (June, 1921).

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Future Growth

The man who could have foretold twenty-five years ago the extent of development which the glass industry has attained today would have been regarded a visionary. In a short space of time we have seen the substitution for hand and lung power of machinery of astonishing perfection in nearly every department of glass manufacturing. We have witnessed the development of the gas producer, the tank furnace and of heat regeneration. Machinery for the handling of raw materials has been invented and is being adopted everywhere. Many new glasses having special properties have been created, such as illuminating glassware, heat resistant glasses, chemical and surgical apparatus, special optical glasses, and many new and beautiful varieties of art glass. There is no phase of the glass industry which has not been changed profoundly during the past quarter of a century.

What new developments may reasonably be expected to come to pass during the next twenty-five years? In the first place we may expect to see the universal adaptation of machinery in those countries which heretofore have clung to the traditional methods. Especially since the close of the war it has been felt that the day of hand labor in many departments of glass manufacturing is past. General use of machinery cannot fail to produce vast improvements. To the boldness of conception of the American inventor will be added the ingenuity and skill of the European, and no one can doubt the final conquest of existing difficulties in the management of molten glass by machinery.

We may expect further improvements in the construction of furnaces, of better cooling and ventilating systems, and of the development of heat resisting materials of greater durability and strength. Especially may we look forward with confidence toward the evolution of many new glasses, having properties as varied as the numerous metallic alloys developed in the last decade. The chemical side of glass making has always been the most hidden; it appeals least to the imagination and quite naturally has been slowest in growth. The pioneer work of Schott and his small band of workers cannot fail to inspire others to further endeavor in the direction indicated by their labors. The glass technologist of today can command resources which greatly surpass the facilities of earlier investigators. The addition of chemicals, hitherto difficult or impossible to incorporate in glass, may become feasible through the wider application of the electric furnace. In view of what the recent past has yielded, can there be any doubt as to the realization of much which at present still remains "such stuff as dreams are made of?"

Technical Consultation Service

THE GLASS INDUSTRY invites its readers to refer to this department any problems with which they may be confronted pertaining to raw materials, glass technology, laboratory and factory practice. While making no pretensions to the possession of unbounded knowledge or infallibility THE GLASS INDUSTRY is ready to assist its readers to the best of its ability in solving their problems. Readers who can offer better suggestions are invited to submit them.

Answers to all questions will be made by mail as promptly as possible. The source of all inquiries will be held in strict confidence.

QUESTION 11—Would it be possible for you to furnish me with a general list of those elements which commonly affect the conductivity of glass?

In the lamp game, we are continuously confronted with the difficulties arising from the electrolysis of glass. This electrolysis occurs across the press; that is, where the lead-in wires pass through the glass and is exaggerated by the temperatures which some of the gas filled lamps reach.

We are consequently very much interested in those elements which may be added to glasses to decrease the conductivity of glasses having a temperature range up to 300° C.

Can you furnish me any information along this line or advise where such information would be available?

ANSWER—We are unable to furnish you with a general list of those elements which affect the conductivity of glass.

It is our understanding that the specific resistance of a glass increases with the percentage of lead oxide and with the density; also that potash gives a lower conductivity than soda. Careful annealing lowers the conductivity of glass. A glass distinguished for its low conductivity had the following composition: Silica, 58.45%; potassium oxide, 9.24%; sodium oxide, 3.74%; lead oxide, 28.02%; calcium oxide, 0.06%; magnesium oxide, 0.05%, and iron oxide, 0.47%.

We refer you to the following articles on the subject:

R. Ambronn, Physikalische Zeitschrift, 1913, Vol. 14, p. 112; and 1918, Vol. 19, p. 401.

R. Ambronn, Annalen des Physik, 1919, Vol. 58, p. 139.

A. Gray and J. J. Dobbie. Proceedings of the Royal Society, 1898, Vol. 63, p. 38; and 1900, Vol. 67, p. 167.

The latter article, which is a study of the connection between the electrical properties and the chemical composition of different kinds of glass, should be especially interesting. The article gives a number of glass analyses.

An article by J. R. Clarke, on the Electrical Conductivity of Glass (reprinted elsewhere in this issue of THE GLASS INDUSTRY) consists of a very full compilation of the published results of investigations in this field, many valuable references being given.

The Laboratory

By J. B. KRAK

Valuation of Phosphates and Fluorides

These substances are used mainly to produce opacity in glass. The oldest opacifiers are bone ash and calcined guano, but their use has decreased much in recent years and artificially made calcium and sodium phosphate is used instead. The latter materials are more uniform in composition and contain fewer impurities, a prerequisite for success in making high grade opaque glassware.

Sodium phosphate, as used in glass making, has the formula $Na_2HPO_4 + 12\ H_2O$. On exposure to air the crystals lose their water of crystallization. The percentage composition is as follows: Na_2O 17.33%; P_2O_5 19.82%; H_2O 62.85%. Of the dry material: Na_2O 43.70%; P_2O_5 49.96%; H_2O 6.34%. Calcium phosphate has the formula $Ca_3(PO_4)_2$ with CaO 54.24%; P_2O_5 45.76%. It is used more than any other phosphatic compound. The following methods of analysis are applicable, with slight modifications, to all phosphates:

ESTIMATION OF P_2O_5.—Phosphoric acid is estimated usually by the molybdate process. For detailed instructions the reader is referred to any standard work on chemical analysis. The molybdate precipitate may be conveniently titrated with standard permanganate or by the alkalimetric method (see Vol. 2, p. 119).

ESTIMATION OF IRON, ALUMINUM, CALCIUM AND MAGNESIUM.—The usual methods of separating these elements are not applicable to phosphates, because all are precipitated as phosphates upon addition of ammonia. A number of methods of separation have been worked out, of which the following is the best adapted to practical demands on account of its rapidity and a fair degree of accuracy:

Transfer a 2.5 gram sample to a 250 cc. graduated flask, dissolve in aqua regia and dilute to volume. Filter through a dry filter and pipette a 50 cubic centimeter aliquot, representing 0.5 gram, into a porcelain dish. Evaporate to dryness, filter and take up with nitric acid and water. Add a few drops of methylorange and enough ammonia to almost neutralize the solution, which, however, must remain distinctly acid. Add saturated ammonium acetate solution until the color changes to yellow and until no further precipitate is formed. Heat nearly to boiling and allow the precipitate to settle. It contains iron and aluminum as phosphates and a small amount of calcium, which is carried down mechanically. The precipitate is dissolved in dilute nitric acid and again thrown out with ammonium acetate. It is now free from lime. The filtrates are combined for the estimation of calcium and magnesium.

SEPARATION OF IRON AND ALUMINUM.—Ignite the precipitate in a platinum crucible over a low flame, taking care not to overheat, as iron phosphate is easily fused. Add about one gram of sodium carbonate, fuse and treat with hot water. The iron remains insoluble as ferric oxide; the aluminum goes in solution as sodium aluminate; the phosphate as sodium phosphate. Filter and weigh the iron as Fe_2O_3 and precipitate the aluminum as phosphate with ammonium acetate. Weigh as $AlPO_4$.

To the combined filtrates from the iron and aluminum precipitations add ammonium oxalate and estimate calcium as calcium oxide. Magnesium can be estimated in the filtrate by adding ammonia and conversion of the precipitate by heating to magnesium pyrophosphate.

In sodium phosphate the moisture determination is important. The material is usually pure.

FLUORIDES.—Kryolite, fluorspar, sodium fluoride and aluminum fluoride are the usual forms in which fluorine is added to the batch to produce opacity. Fluorides of sodium and aluminum are soluble in water and the fluorine can be precipitated by adding a few drops of formic acid, followed by a large excess of lead chloride solution. The precipitate of lead chlorofluoride is filtered in a Gooch crucible and washed with lead chloride solution, dried at 140° C. and weighed as PbFCl.

The accurate estimation of fluorine in kryolite and fluorspar is one of the most difficult problems in quantitative analytical chemistry. It requires considerable apparatus. For detailed descriptions of the different methods the reader is referred to the works on quantitative analysis by Fresenius and Treadwell. The Bidtel method for the analysis of fluorspar meets the commercial requirements for the valuation of this material. (See Journal Ind. Eng. Chem., Vol. 4, No. 3.)

Recent Patents

NEW INVENTIONS DESIGNED TO IMPROVE GLASS AND THE MEANS OF PRODUCING IT

Copies of the Patent Specifications mentioned below may be obtained from the Commissioner of Patents, Washington, D. C. Price 10c. each.

Method and Apparatus for Making Glass Articles. U. S. 1,382,994. June 28, 1921. Clyde R. Lott, of Washington, District of Columbia, assignor to the Guardian Trust and Savings Bank of Toledo, trustee, of Toledo, Ohio.

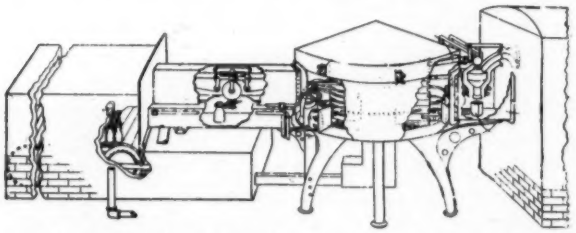
This invention is a process of, and apparatus for, making and manipulating glass and other articles, but it is particularly adapted for making glass bottles, jars, etc.

The invention enables a certain quantity of molten glass to be drawn off automatically, from a furnace or other receptacle, automatically shaped, and delivered to, and through, an annealing apparatus, and in a practically continuous manner, thereby both expediting and economizing in the manufacture of the articles under consideration.

So far as shaping the glass is concerned, this operation may be performed in a press, or the glass may be subjected to a preliminary pressing operation, and the final shaping accomplished by "blowing."

The several operations of molding or shaping the glass, delivering the shaped articles to and through the annealing furnace, etc., are performed in chambers containing air, the temperature of which is to be predetermined, thereby producing more durable and perfect ware, thereby preventing chilling of the article, and avoiding the large percentage of loss, incident to performing one or more of the specified operations in the open air.

Among the important features of the invention may be mentioned the automatic means for drawing the glass from the furnace, the mechanism for shaping the same, the carrying devices for delivering the shaped articles to the annealing furnace, and the novel features of construction embodied in the conveyer and said annealing furnace.



Other features herein disclosed are set forth and claimed in my Patents Nos. 1,338,992, May 4, 1920, and 1,369,679, February 22, 1921, and in my co-pending applications as follows:

Ser. No. 244,684, filed July 13, 1918, making glassware.

Ser. No. 259,419, filed October 23, 1918, means for working molten glass.

Ser. No. 365,784, filed March 15, 1920, means for shaping glass articles.

Ser. No. 349,922, filed January 7, 1920, means for producing charges of molten glass.

Ser. No. 365,785, filed March 15, 1920, method and apparatus for flowing molten glass.

Ser. No. 365,786, filed March 15, 1920, temperature controlling and lubricating means for mold plungers.

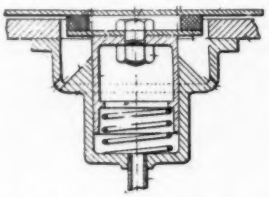
Glass-Cutting Apparatus. U. S. 1,385, 732. July 26, 1921. William Taylor, of Leicester, England.

This invention relates to apparatus for sawing glass, and more particularly to apparatus for cutting disks from sheets of glass and similar material, as in cutting from sheets or plates of optical glass disks for making lenses.

The objects of the invention are generally to control the approaching movement between the work and the saw so as to prolong the working life of the saw while securing a maximum rate of cutting; to provide an improved disk-cutting saw; to provide an improved means for lubricating the saw with a washing and cooling liquid; to provide improved means for holding the sheet of glass or other material from which disks are to be cut; and in general, to provide an improved machine or apparatus which is highly efficient in operation and convenient to manipulate.

Apparatus for Grinding and Polishing Plate-Glass. U. S. 1,384,278. July 12, 1921. Frank Edwin Slocombe, of St. Helens, England, assignor to Pilkington Brothers, Limited, of St. Helens, England.

This invention relates to apparatus for grinding and (or) polishing plate glass and has for its object to provide an improved form of sucker device for fixing the glass on to the table or disk on which it is to be ground or polished.

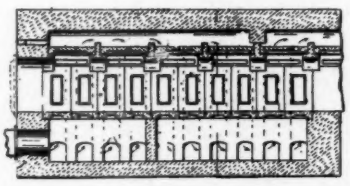


Heretofore it has generally been the custom to secure glass plates on the grinding or polishing tables by bedding them down on to a layer of cement laid on the table or on to a layer of some soft fabric. To prevent the glass flying off under centrifugal force, a ring of holes is provided at the edge of the table into which wooden pegs are driven, and the spaces between the plates of glass to be ground or polished and these wooden pegs are filled in with pieces of glass.

According to this invention, the glass plates are held on to the surface of the table by suckers of an improved form attached to the table, so constructed as to flatten any plate which may have become curved or buckled in the annealing, and so obviate the need for a bedding material such as above mentioned.

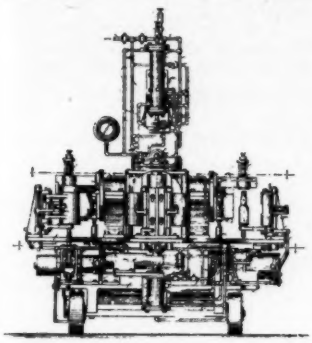
Muffle Lehr Construction. U. S. 1,385,868. July 26, 1921. Paul L. Geer, of Bellevue Borough, Pennsylvania, assignor to Amsler-Morton Company, of Pittsburgh, Pennsylvania.

The invention relates to a muffle lehr in which the combustion of the gaseous fuel takes place under the forward end of the muffle, the products of combustion being led upwardly through vertical flues at the sides of the muffle to the crown, and thence downwardly through reverse flues to a chamber in the rear of and separated from the combustion chamber. Thence the products are led up through flues at the sides of the muffle to the rear portion of the crown which is separated from the forward portion of the crown by a baffle or intersecting wall, and thence said products pass along the crown extension to the stack in the rear of which is the tunnel which extends to the discharge door of the lehr. The third or rear series of vertical flues are preferably of less capacity or fewer in number than the first and second named series to prevent too rapid passage of the products of combustion. The travel of the products of combustion is further regulated by the stack damper, while the intensity of the heat in the combustion chamber is regulated by the air and gas valves of the burner, where a gas burner is used.



Machine for Making Glass Bottles. U. S. 1,385,428. July 26, 1921. Charles F. Cox, of Bridgeton, N. J.

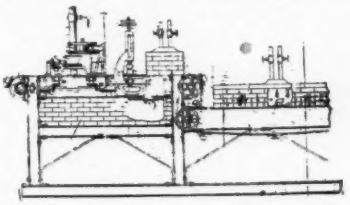
This invention relates to a machine for making glass bottles of any desired form or size and to certain novel mechanical combinations in such a machine whereby are accomplished ertain novel modes of operation. More particularly the invention relates to mechanical combinations in a machine as aforesaid, such that the machine will operate in a substantially automatic and continuous manner in carrying out all the various detailed operations necessary to the production of a finished bottle and so as to require substantially no attendance other than that required to supply the machine with molten glass, to start the machine, and to remove the finished bottle.



The object of the invention is to provide a machine of the character described which shall be comparatively simple in its construction, thus being little liable to get out of order, and positive and certain in its operation. A further object is to provide such a machine which shall work quickly and, therefore, have a large capacity. A still further and most important object is to provide a machine which shall be substantially automatic in its operation, so that but little attendance is required and that not of a skilled character, while, at the same time, the product turned out by the machine is uniform and accurate.

Apparatus for the Manufacture of Glassware. U. S. 1,384,-967. July 19, 1921. William H. McSwain, of Moundsville, W. Va.

This invention relates broadly to glass making apparatus, and more particularly to a machine for the automatic manuafcture of pressed articles of glass-ware.



The primary object of the invention is to provide a machine designed for automatically performing all of the various operations required in the manufacture of pressed articles of glassware from the flowing of the glass from the melting tank or pot to the production of the finished articles.

A further object is to provide a machine of simple and comparatively inexpensive construction adapted for the continuous and rapid handling of the glass in an efficient and economical manner without human intervention.

Recent Deaths

Chester L. Sharp

The many friends of Chester Lee Sharp, president of the Sharp-Schurtz Company, Lancaster, Ohio, were shocked and grieved to learn of his untimely death, as a result of an attack of pleuro-pneumonia, on Thursday, August 25, at the City Hospital at Lancaster. Mr. Sharp had caught a severe cold early in August which became critical and necessitated his being taken to the hospital, where he underwent a surgical operation on August 22, from which he failed to rally.

CHESTER LEE SHARP

His death at the age of thirty-two cut short a successful and promising career and his going is a distinct loss to the industry, where his influence was always for progress and betterment, and throughout which his opinions and advice on engineering problems and plant operation were constantly sought and highly esteemed.

Mr. Sharp acquired his education at the public schools of Cedar Grove, Ohio, and at Ohio State University at Athens, and Heidelburg University, at Tiffin, Ohio. After leaving college he took a job pushing a wheelbarrow at the works of the Columbus Glass Company in East Lancaster. The late William Campbell, then at the head of the company, soon recognized his character and ability, gave him opportunities and responsibilities, and before long he was in charge of the mechanical engineering department of the plant. Sharp, as he preferred to be called, went later to Ball Brothers Company, at Muncie, Indiana, as designing and erecting engineer. From there, he returned to Lancaster and became secretary of the Frink Laboratories and continued with this organization and the Frink Pyrometer Company until the departure of R. L. Frink to become Director of Research for the British Glass Research Association. When this occurred, Mr. Sharp and D. D. Schurtz, a well known chemist, purchased the Frink Laboratories, incorporated the Sharp-Schurtz Company and carried on the business since then with marked success, adding to their consulting and laboratory work, the manufacture of a large number of chemical and other specialties for glass manufacturers.

His country and his home community will miss Mr. Sharp, for he was a truly good citizen, taking an active part from an early age in many public-spirited movements, and being particularly interested in the welfare of boys and the Boy Scouts organization in which he had filled various offices.

Mr. Sharp leaves a widow, Mrs. Georgia Cook Sharp, and a daughter, Phyllis, aged six years. His father and a sister also survive him.

CHARLES P. TERHUNE, president of the Cincinnati Plate Glass Company, Cincinnati, Ohio, died at his home on August 22nd. after an illness of more than a year.

MARTIN BACH, SR., proprietor of the Quezal Art Glass & Decorating Company, Brooklyn, N. Y., died on August 1. Mr. Bach, who was 59 years of age, was born in Lorraine, France, and been in the decorative glass business for a great many years.

Glass Factory Equipment and Supplies

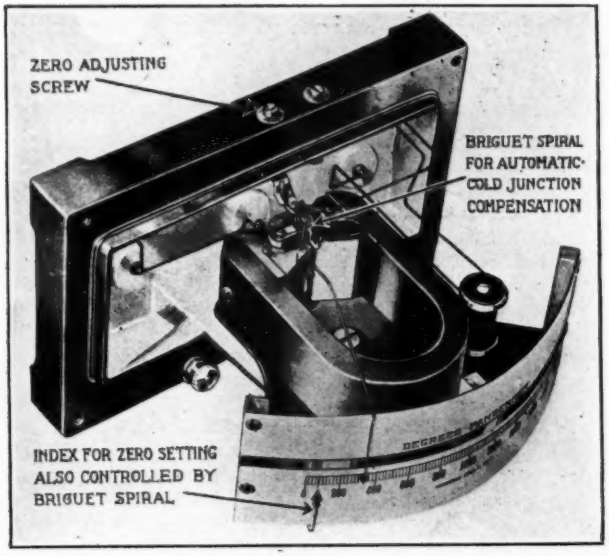
THE GLASS INDUSTRY will be glad to publish descriptions of new and useful devices, machinery and supplies of interest to the glass manufacturing trade. Most of the information printed in this department comes direct from the manufacturers of the products described.

New Brown Cold Junction Compensated Pyrometer

By R. P. BROWN*

The Brown Instrument Company, Philadelphia, Pa., is placing on the market a new thermo-electro pyrometer, which is automatically compensated in the instrument for changes in cold junction temperatures and which includes means of setting the pointer of the instrument to zero in the usual manner.

This is an improvement on the method of cold junction compensation developed by Darling in England in 1909, and an improvement on a few subsequent developments for automatic cold junction compensation brought out since that time. These former methods afforded no means of setting the instrument to zero. It is customary on all electrical instruments, including millivoltmeters and pyrometers, to supply a zero adjustor to enable the user to set the instrument to zero, provided the zero


ZERO ADJUSTING SCREW
BRIGUET SPIRAL FOR AUTOMATIC COLD JUNCTION COMPENSATION
INDEX FOR ZERO SETTING ALSO CONTROLLED BY BRIGUET SPIRAL

INTERIOR VIEW OF BROWN COMPENSATED PYROMETER

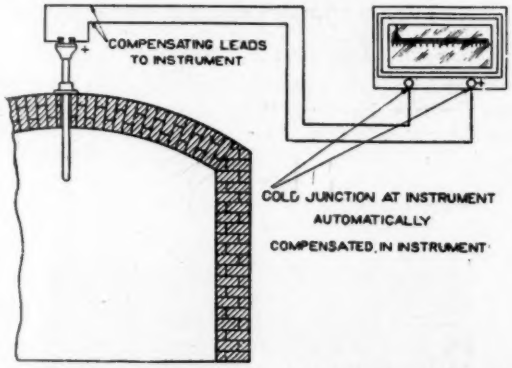
has shifted, due to jars in transportation or with continual service. The Brown method is the only one which embodies this most necessary feature.

Darling used what is called a Briguet spiral, a compound strip of two metals of different coefficient of expansion. The Briguet spiral was used to move the scale dependent on the change in atmospheric temperature surrounding the instrument, or as an alternative, this Briguet spiral was mounted to act on the springs controlling the moving element of the galvanometer. Darling's device was never used to any extent because it was evident that unless an instrument had a means of setting to zero, serious errors might result in the use of the instrument. Suppose, for example, the instrument pointer was standing at 110°F., was the pointer standing at this position on the scale because the temperature surrounding the instrument was 110°F., or was the temperature surrounding the instrument only 90°F. and the zero had shifted 20°? Naturally, no accurate temperature instruments could be secured with this element of doubt.

The new Brown construction, patented December 28, 1920, includes a means of setting the instrument to its proper zero. This is clearly set out, for example, in Claim 1, as follows: "In an electrical instrument, a pointer, a scale operatively arranged with respect to said pointer, means to automatically compensate said scale for changes in temperature surrounding said instrument and means for establishing a normal zero, whereby said pointer can be set to zero."

It is generally understood by all users of thermo-electric pyrometers that the millivoltage or e. m. f. developed by a thermo-couple is dependent on the difference in temperature between the hot and cold ends of a thermo-couple. To secure accurate measurements of temperature, it is therefore necessary that the cold end of the thermo-couple be maintained at a constant temperature or the instrument must be compensated for the changes in temperature at the cold junction of the thermo-couple.

It is common practice to use what are known as extension or compensating leads, formed of material similar to the thermo-couple, which will transfer the cold junction from the binding



WIRING DIAGRAM OF BROWN COMPENSATED PYROMETER

posts of the thermo-couple to a distant point. Heretofore, it has been necessary to locate the cold junction at the end of the extension or compensating leads in a cold well in the ground or in a compensating box, where the temperature can be maintained constant.

If the new Brown pyrometer, compensated for changes in temperature of the cold junction is used, the extension or compensating leads are brought to the meter. Changes in temperature at the end of the extension or compensating leads also take place in the meter itself, which can be compensated for this change in temperature.

There are two methods by which this compensation can be easily secured. A portion of the scale of the instrument may be mounted on thermostatic material and moved, dependent on the change in temperature of the meter and in this way automatic compensation may be secured. Only a portion of the scale is moved and an index on the other portion of the scale denotes the normal zero of the instrument.

A Briguet spiral similar to that used by Darling may be mounted in the instrument, controlling the springs and moving element directly, and a second index controlled by thermostatic metal may be mounted on the scale. This index works with change in temperature exactly in relation to the movement of the pointer controlled by the Briguet spiral attached to the moving element.

In using the new Brown pyrometer compensated for cold

*President, Brown Instrument Company.

junction changes in temperature, it is only necessary to bring the compensating or extension leads from the thermo-couple to the instrument. After mounting the instrument, the instrument pointer is set by the zero adjustor to correspond with the index on the scale. If the values for a thermo-couple have been determined based on a cold junction of 75°F., the index will indicate 75°F., provided the instrument is subject to this surrounding temperature. If the instrument pointer does not correspond with this index, it is set accordingly. When the temperature surrounding the instrument and the cold junction of the end of the compensating leads at the instrument rises to 90°F., the index automatically rises to 90°F., and the Briguet spiral attached to the instrument pointer causes it to move up to 90°F., automatically adjusting for the temperature of the cold junction of the thermo-couple.

It will be understood that any number of thermo-couples with their extension or compensating leads can be brought to the one instrument having this automatic compensation. Likewise, recording instruments can be equipped with this automatic compensation and means for setting the pointer to zero.

This improvement in thermo-electric pyrometers will be appreciated by the many users of these instruments who are confronted with the difficulty of maintaining a constant cold junction temperature.

The Thwing Radiation Pyrometer

The indicating and recording of low temperatures such as obtained in lehrs and ovens is comparatively easy. At these temperatures base metal thermocouples are practically indestructible.

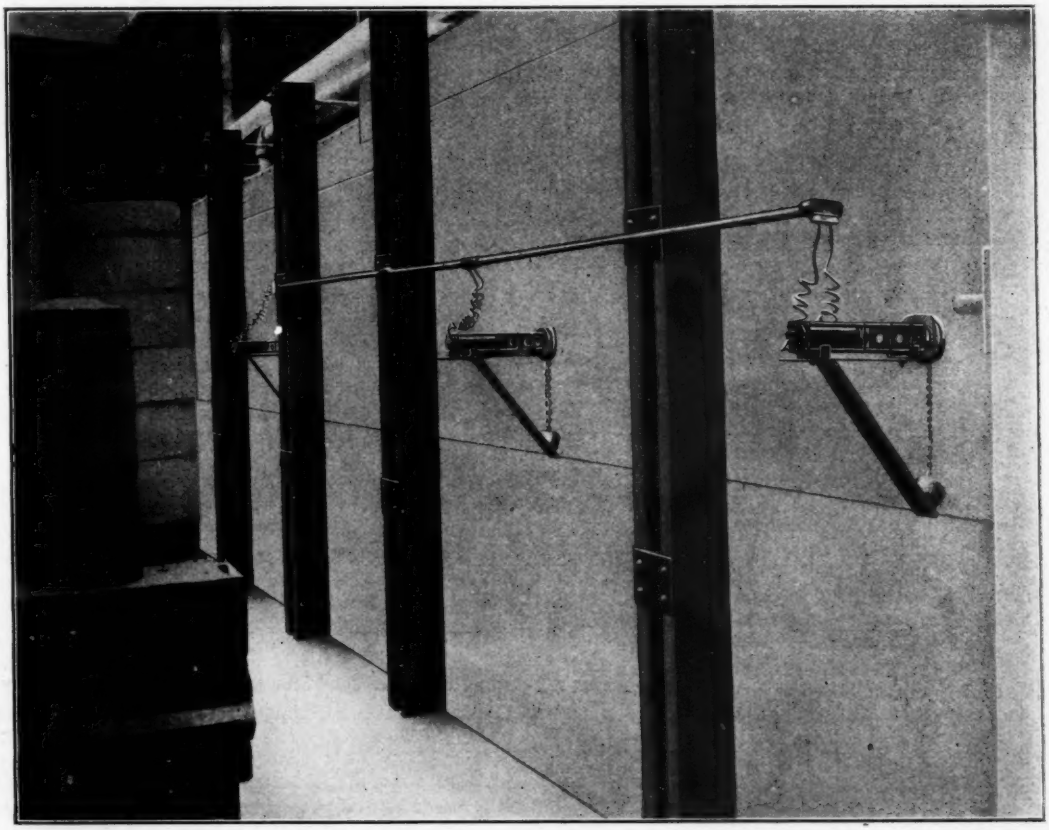
The measurement of the high temperature found in melting tanks is a much more difficult and expensive matter. Platinum is the only metal available and platinum is very expensive.

If the temperature is to be measured any distance within the furnace long thermocouples must be used and the liability of breaking the porcelain and fire clay protecting tubes is greatly increased.

To overcome the high maintenance cost of these couples the Thwing radiation pyrometer has been developed by Dr. Charles B. Thwing, president, Thwing Instrument Company, Philadelphia, Pa.

It is claimed that this pyrometer is indestructible, not because it is built of highly refractory materials but by virtue of the location of the heat sensitive element which is not inserted in the furnace but supported in front of a small opening in the furnace walls, where it collects the heat radiations from the surface of the metal itself. The radiant energy thus collected is concentrated on the junctions of a very sensitive thermopile, whose current registers temperatures on a distant recorder.

The mirrors are so designed that the indications of the instrument are independent of the distance of the object, so that it is possible to point the tube at the centre of the bath if desired.



AN INSTALLATION OF THWING RADIATION TUBES

It measures the temperature of the metal itself rather than that of the furnace gases.

The radiations are received through a mica window which closes the end of the receiving tube, thus protecting the mirror from dust and fumes.

The makers of this pyrometer state that there is no upper limit to the temperatures which it will measure and that it has been successfully used for measuring temperatures up to 3000 degrees C. (5400 F.) in the electric furnace, without the slightest damage to the instrument.

Proposed Changes in Container Shipping Rules

The August bulletin of the National Glass Container Traffic Association gives the following information:

The Consolidated Classification Committee has just issued a *special docket* containing 43 pages devoted entirely to shipping containers. It contains:

Proposed revision of fibre container rule 41.
Proposed specifications for nailed and lock corner boxes.
Special specifications for nailed boxes for glass bottles.
Proposed general specifications for wire bound boxes.
Detailed specifications for wire bound boxes to carry food in metal cans.

Hearings will be held as follows:

1830 Transportation Building, Chicago, Sept. 20th, 1921.
Room 408, 143 Liberty street, New York, Sept. 26th, 1921.
Hotel Ansley, Atlanta, Georgia, October 26th, 1921.

The proposed changes in Sec. 8, Rule 41, Glassware and Articles in Glass, are quoted below in full:

"SECTION 8. (a) Glassware, other fragile articles or articles in glass or earthenware packed in fibreboard, pulpboard or double-faced corrugated strawboard boxes must not exceed 65 pounds gross weight and inner and outer flaps must meet or overlap and contents so packed as to completely fill the box; and

"(b) Liquids in glass or earthenware containers exceeding one quart capacity or in other containers exceeding one gallon capacity will not be accepted for transportation except than when glass or earthenware container exceeds one quart, but does not exceed one gallon capacity, it will be accepted in double-faced corrugated strawboard boxes when the quantity does not exceed four gallons; and

"Each such container must be enclosed in a double-faced corrugated strawboard carton and all sides of box must be lined with one piece of double-faced corrugated strawboard properly scored; or

"Each such glass or earthenware container must be enclosed in a scored shell of double-faced corrugated strawboard and all sides of box must be lined with one piece of double-faced corrugated strawboard properly scored; the top and bottom of box must also have a liner of double-faced corrugated strawboard or excelsior lined paper pads extending to both sides and ends of the box, placed inside of the flaps.

"(c) Glassware, other fragile articles or articles in glass or earthenware must be enclosed in wrappers made of

Double-faced corrugated strawboard, or
Cork-lined strawboard, or
Excelsior-lined paper, or

must be separated by tightly fitting partitions which touch all sides, top and bottom of box, made of

Double-faced corrugated strawboard, or
Flexible wood, or

must be securely packed with excelsior, hay or straw and all boxes must be lined with double-faced corrugated strawboard on all sides, top and bottom, unless two complete double-faced corrugated strawboard boxes or double-strength strawboard boxes or inner cartons made of double-faced corrugated strawboard are used; or

"(d) When articles in glass or earthenware containers are of one pint or less capacity, each such container must be enclosed in a carton or wrapper and then enclosed in a second carton which must be completely filled. Contents of the containers in the second carton must not exceed the equivalent of six pints. Each second carton must be separated by tight fitting double-faced corrugated strawboard or flexible wooden partitions touching all sides, top and bottom of the box; sides, top and bottom of the box must be lined with double-faced corrugated strawboard or excelsior-lined paper pads unless two complete double-faced corrugated strawboard boxes or double strength boxes as described in this rule are used; when such cartons are made of double-faced corrugated strawboard and completely fill the box, partitions will not be required and the sides, top and bottom of the box need not be lined."

Note excelsior, hay or straw packing is provided for articles in glass any weight and provision is made for pads and liners for all containers except double boxes or double strength.

The manufacturers of fibre containers are very active through their associations in connection with this docket. They will request a number of changes.

The August bulletin also quotes in full the general and special specifications for nailed and lock-cornered boxes for food in metal cans and glass bottles proposed by the National Association of Box Manufacturers.

National Exposition of Chemical Industries

Four hundred exhibits of chemicals and of supplies, apparatus and equipment used in the chemical industries will be made at the Seventh National Exposition of Chemical Industries at the Eighth Coast Artillery Armory, New York City, during the week of September 12th. The scope and importance of this annual event has increased year by year and next month's display is expected to eclipse all previous records.

Manufacturers, technical and scientific men and students to the number of 50,000 are expected to attend, many coming from abroad. Those from Great Britain will be taken care of by a co-ordinating committee of Canadians and Americans, who will escort them to Niagara Falls and other points of interest, including a visit to the Solvay Process plant at Syracuse, N. Y.

All phases of the chemical industries will be covered. The program for the week includes meetings of various chemical societies, industrial motion pictures, including one by courtesy of the Corning Glass Works, showing the manufacture of Pyrex glassware, and many other activities.

Glass and its chemical and industrial relations will be in evidence. Displays will be made of optical, photographic and scientific instruments, lenses, range finders, gun sights, search light reflectors, and many other products.

Dishes made from a glass composition which is entirely unaffected by nitric, sulphuric and hydrochloric acids, regardless of temperature or concentration and offers great resistance to the action of phosphoric acid, casseroles perfected to meet the requirements of chemical and steam baths, will, it is expected, be a part of this comprehensive display.

Materials handling problems will be given special attention. The importance of proper packing and shipping will be emphasized by displays of containers made by concerns which have made intensive studies of the problems involved. Barrels, kegs, bottles, fibre cases and other types of containers will be shown. A machine for labeling bottles, packages and boxes as they come from the filling machines will be exhibited.

A. C. S. Has Full-Time Secretary

At the banquet held during the summer meeting of the American Ceramic Society at Canton, Ohio, July 25-27, President Pence announced the appointment by the board of trustees of Ross C. Purdy to act as full-time secretary. Mr. Purdy is to serve until the end of this year as organizing secretary and in 1922 as general secretary.

During the week of the Chemical Exposition, September 12-17, an important conference will be held of the officers and committee members of the American Ceramic Society, under the leadership of the new organizing secretary, Mr. R. C. Purdy. The meeting will convene at the Hotel Commodore, New York City, on Thursday morning, September 15, at nine-thirty. Discussion of the "Program of Activities" will occupy the day.

On Friday, committee meetings or special gatherings will occur and the program at the Chemical Exposition will be under the auspices of the American Ceramic Society. Papers on Chemical stoneware, chemical porcelain, refractories, etc., will be read and in the evening industrial motion will be shown.

Plate Glass Propaganda

Believing that material benefits will result from co-operative publicity, the Plate Glass Manufacturers of America have inaugurated an advertising campaign having for its object the influencing of the trade and the ultimate consumer to replace broken automobile windshields and windows with plate glass. This is the first time that a concerted effort has been made to point out the virtues of plate glass to the consuming public.

The plan involves the use of popular magazines of national circulation for an advertising campaign, the use of the mails to advise all wholesalers and retailers of what is being done and the advising by letter of all motor car manufacturers regarding the progress of the campaign. The idea being that these manufacturers will be anxious to see that replacements in their cars are made with plate glass in order that the replacements will equal in quality the original equipment. Included in the plan, for the use of retail outlets, a series of small garage advertisements has been prepared. These advertisements are unique in that they are essentially local garage advertisements. "Mats" of them will be furnished free to garages that wish to use them in their local newspaper advertisements. In these advertisements plate glass is mentioned in a somewhat incidental manner as if to show the completeness of the service offered by the particular garage that is doing the advertising.

Some of the copy for the national advertising campaign has already appeared in *The Saturday Evening Post*, half-page space being used in each case. In this series, the virtues of plate glass are pointed out graphically. Besides the beauty and attractiveness inherent in plate glass, the fact has been emphasized that this material is free from large flaws, hills or hollows, and of a quality that makes for sure and easy driving. A point has been made also of the uniform thickness of plate glass which makes it unnecessary to force a light into place in its frame. The claim is also made that this characteristic causes plate glass to stand the shocks of the road.

A feature of each advertisement is that the last paragraph is used to describe some other use to which plate glass has successfully been applied. N. W. Ayer & Son, the well known advertising agents of Philadelphia, Pa., are in charge of the plate glass campaign.

Striking results in increased consumption have been obtained in a number of other industries by co-operative advertising backed by the manufacturers of the products advertised, and the results accruing from the plate glass advertising campaign will be of decided interest to other branches of the glass industry.

Trade Association Limitations

The National Association of Manufacturers addressed a letter on July 25 to Secretary of Commerce Hoover requesting that a statement be issued by the Department giving the governmental viewpoint as to what trade associations may legally do with respect to gathering and distributing statistical data on production, consumption, etc. The letter points out that a provision of the Census Act of March 3, 1919, calls for the collection and publication of statistics of manufactured products. It is expected that in the near future the administration may issue an authoritative announcement on this subject.

Cost Conference

The second international cost conference is to be held at Cleveland, Ohio, September 14 to 16, under the auspices of the National Association of Cost Accountants. Several of the sessions will be open to the general public. Uniform cost methods and standardized costs will be discussed. Copies of the program may be had at the national offices of the association, 130 West 42nd street, New York.

News of the Trade

THE GLASS INDUSTRY will be glad to receive notices of new glass manufacturing projects, plant extensions, removals, personal items, etc.

The capital of the GAYNER GLASS WORKS of Salem, N. J., has been increased from $150,000 to $500,000.

THE OHIO FLINT & GLASS SAND COMPANY has been incorporated at Zanesville, Ohio, with a capital stock of $100,000.

THE ATLANTIC BOTTLE COMPANY, 90 West Broadway, New York, manufacturer of glass bottles, has increased its capital stock from $60,000 to $300,000.

The general office of the AMERICAN BOTTLE COMPANY, formerly in the First National Bank Building, Chicago, Ill., is now located in the Nicholas Building, Toledo, Ohio.

The death of Chester L. Sharp, president of SHARP-SCHURTZ COMPANY, Lancaster, Ohio, will not cause any change in the policy or operations of the business, which will continue to be conducted under the same name.

THE BONITA ART GLASS COMPANY, recently organized at Wheeling, W. Va., is planning the erection of a new plant, consisting of two buildings, 60 by 80 feet each, according to a press report.

THE CAMERON GLASS COMPANY has been incorporated at Cameron, W. Va., with a capital stock of $60,000. The incorporators are: James A. Frank, James F. Donahue, James A Whelan, Mrs. J. F. Whelan and R. T. Straub.

THE CALIFORNIA GYPSUM CORPORATION, 731 Pacific Finance Building, Los Angeles, Cal., expect to erect a new plant at Coyote Wells, Imperial County, at an estimated cost of $650,000. The plant will be used for manufacturing gypsum products.

According to a press report, the OHIO CENTRAL GLASS COMPANY, Cincinnati, Ohio, has been incorporated with a capital stock of $30,000. The incorporators are: Albert Fowler, C. J. Mattern, Elizabeth Rowland, Ruth Pansing, R. N. Brumbaugh.

According to a recent report, construction work has been completed on the steel factory building adjoining the foundry of the GEORGE J. HAGAN COMPANY at Orrville, Ohio, which will be used for developing and constructing furnaces and furnace equipment.

Reports that William C. McCarthy and Eugene McCarthy of Millville, N. J., are contemplating the establishment of a factory for the manufacture of vacuum bottles, are stated by William C. McCarthy to be premature, no detailed information being available at this time.

It is reported that the plant of the WASHINGTON GLASS MANUFACTURING COMPANY, Anacortes, Wash., has been leased by J. E. Jensen and associates. The plant will be remodeled and additional equipment installed and used for the manufacture of glass specialties.

THE VICTOR LENS MANUFACTURING COMPANY, Camden, N. J., according to press reports, has been incorporated with a capital of $125,000, by Clifford A. Baldwin, George D. Rothermel and Albert E. Burling. The company will manufacture lenses and other glass products.

The plant of the BROWNSVILLE WINDOW GLASS COMPANY, Brownsville, Pa., was destroyed by fire on August 6th. W. S. Phillips, general manager of the plant, states that the loss is estimated at about $300,000 and that as yet the company has not decided what to do regarding rebuilding and future plans.

A. F. Brady, vice-president and treasurer of the HAZEL-ATLAS GLASS COMPANY, states that the reports to the effect that a new building is to be erected on property recently acquired adjoining their Wheeling, W. Va., plant are inaccurate. The company does not have any plans for adding any new buildings to the Wheeling plant at this time.

WM. J. MILLER, Swissvale, Pa., manufacturer of the Miller bottle machine and automatic feeder, announces that W. F. Cargo, Jr., who has been acting as foreign salesman, is no longer in his employ. His financial agent, S. H. Rylett, is temporarily acting in this capacity and all communications addressed to the London office, 2, Southampton street, Strand, W. C. 2, will be promptly responded to.

THE RAVENSWOOD GLASS COMPANY, Chicago, Illinois, has increased its capital stock from $10,000 to $50,000, in order to take care of the increased business it has acquired during the past eight months. The company has moved to its new home at 1421-23 Center Street, on the C. M. & St. P. R'y. The company makes a specialty of furnishing glass to the sheet metal trade and glaze industrial plants all over America.

The initial issue of *Lighting Fixtures and Lighting*, a new monthly trade journal devoted to the interests of the dealers in lighting fixtures, portables, lamps and glassware, made its appearance recently. Its make-up is attractive and the contents cover in an interesting way many subjects of interest to the trade. James Krieger is the publisher and Julian Rosenthal editor. The publication office is at 175 Fifth avenue, New York.

THE TIDEWATER GLASS COMPANY was recently organized at Pittsburgh, Pa., with Harry A. Neff, of the Belmont Tumbler Company, Bellaire, O., president; J. O. Erskine, vice-president, and B. R. Kessler, secretary. The company expects to erect a plant at Jacksonville, Fla., as it is stated that tests of sand taken from the seashore near that city indicate that it has a high percentage of silica. It is also reported that on account of the location, Cuba will probably be able to absorb a large portion of the output of the plant.

Construction work on the new plant of the DAVIES GLASS AND MANUFACTURING COMPANY, Martins Ferry, Ohio, has been resumed as a result of the decision of the structural iron workers to return to work at reduced wages. The concrete pouring had been completed but other construction has been delayed since the first of May as a result of the strike. The plant is located on the site of the old Haskins glass factory and it is expected that it will be completed within three or four months. The company will manufacture all the products of the Dillon Lens Company.

C. O. Grander announces that the Spring City Glass Works, Ltd., of Spring City, Pa., a partnership which, as announced in our July issue was recently dissolved, was reorganized and incorporated under the laws of the State of Pennsylvania as the SPRING CITY BOTTLE COMPANY.

The officers of the company are: John Keyser, president; Arthur Westcott, vice-president; William G. Kline, treasurer; Clarence O. Grander, secretary, and O. B. Finkbiner, manager, who states that the company contemplates installing automatic machinery and flowing devices.

THE OPTICAL ABRASIVE COMPANY, Southbridge, Mass., has been organized by J. J. Hogan, Jr., and J. E. Lowe, to manufacture high grade lens grinding abrasives for the optical trade. They have purchased a factory building at Charlton, Mass., equipped with water wheel power, and expect to begin the marketing of their product about October 1st. Mr. Hogan, for the past fifteen years, has been connected with the American Optical Company of Southbridge, Mass.; ten years as secretary to the general manager of the lens plant and part of the time on lens production work. Mr. Lowe has been in charge of handling all abrasives for the American Optical Company for the past nine years.

Hazel-Atlas Affairs

Referring to the rumors current during the summer to the effect that control of the Hazel-Atlas Glass Company had passed to a competitor, the Wheeling, W. Va., *News*, of July 31, said:

> Among the Wheeling stockholders of the Hazel-Atlas Glass Company, there has been much interest during the past few days over various rumors and apparently semi-official reports concerning the consolidation of the Hazel-Atlas Glass Company, with other large glass enterprises in the same line of business. *The News* is able to state on absolutely authoritative information that while this project has been and is under consideration at the present time, there is nothing definite to be given out, indicating immediate consummation of the deal.
>
> The plan contemplates the consolidation of the Hazel-Atlas Glass Co. with Ball Brothers & Company, very large manufacturers of fruit jars, located in Indiana, and the Illinois Glass Company, another very large manufacturer of jars and bottles. Both of these concerns operate in lines that are somewhat competitive with those of the Hazel-Atlas Glass Company, but on the other hand all of them have distinctive lines of their own. Ball Brothers are the largest manufacturers of fruit jars in the world, in this specialty, exceeding the volume of business of the Hazel-Atlas in the same line. The Illinois Glass Company produces a line of narrow neck bottles, and has a very large trade in that particular specialty. During the past week, a decision rendered by the United States Court, giving to the Hazel-Atlas Glass Company the unrestricted license rights of certain machines used by the Illinois Glass Company, probably makes the Hazel-Atlas a strong competitor in these lines of the Illinois company.
>
> It is recognized that some very distinctive advantages would come from a combination of the three companies, both in manufacturing economies and in the higher development of their specialties. The situation at present, however, does not justify the statement that this or any other consolidation is certain to be made. Influential interests in the three corporations have considered the matter and discussed it informally, and some steps have been taken to fix the relative basis of consolidation.
>
> At the present time both Mr. W. S. Brady and Mr. J. C. Brady, the most influential factors in the Hazel-Atlas Glass Company, are absent from the city and will continue so for several weeks. It is, therefore, regarded as certain that no conclusive developments in the project will occur within the next few weeks.

Personals

R. F. BRENNER, chief chemist of the Bartlett-Collins Glass Company, Sapulpa, Okla., has severed his connections with that concern and is now connected with the H. C. Fry Glass Company, Rochester, Pa., in the same capacity.

E. E. COLLINS, of Rochester, N. Y., for the past fifteen years manager of the Reed Glass Works, has taken charge of the NORFOLK GLASS MANUFACTURING COMPANY'S plant at Newton Park, Berkley, Va. Mr. Collins is making a number of important changes in the plant at Newton Park and the company reports that they will start operations shortly with a full force of men. Sloan R. Hall, formerly with the Jeannette Glass Company, Jeannette, Pa., is general manager.

ALBERT Y. GOWEN, JR., of the Kelly Island Line & Transportation Company, Cleveland, Ohio, left New York a few days ago accompanied by Mrs. Gowen for a 50,000-mile cruise around the world on Mr. Gowen's 98-foot motor yacht *Specjacks*. The yacht flys the flag of the Adventurers' Club and the voyage will last a year and a half. After passing through the Panama Canal the party will head for the Marquesas Islands, a distance of 3,729 miles and a record attempt for a boat of this kind. Many out of the way places will be visited.

F. S. CROSBY, sales and advertising manager for the United States and Cuban Allied Works Engineering Corporation has resigned to become manager of the Eastern District of the Celite Products Company, producers of Sil-O-Cel insulating material, and Filter-Cel filtering medium. Previous to his

service in France with the army, he was assistant sales manager for the De Laval Steam Turbine Company of Trenton, N. J. Mr. Crosby will make his headquarters at 11 Broadway, New York.

S. B. Henshaw Leaves Libbey-Owens

S. B. Henshaw, general factories manager of the Libbey-Owens Sheet Glass Company for a number of years during the perfection at their Charleston, W. Va., plant of the Colburn process of drawing sheet glass, has severed his connection with the company and is succeeded by Thomas C. McKinley, formerly manager of the American Window Glass Company plant at Bellevernon, Pa. No announcement has been made of Mr. Henshaw's plans for the future.

Technical Catalogs Wanted

The director of the Government industrial school for mechanicians and commercial students at Vigo, Spain, would be pleased to receive any catalogs and magazines (preferably, but not necessarily, in Spanish) having to do with machinery and mechanics, that American firms may care to send him. Send communications to the following address: El Sr. Director de la Biblioteca, Escuela de Artes y Oficios, Vigo, Spain.—*Commerce Reports.*

Inquiries Received

Further particular may be obtained from THE GLASS INDUSTRY.

No. 32—We would like to get quotations on 5,000 globular glass pieces, about 3½ inches in diameter and 3¾ inches high, open at bottom, pressed or blown. These are to be utilized, in a new device which, when successfully introduced, will call for large quantities of similar pieces.

No. 33—I have been instructed by my principals in France to obtain all information available concerning glass manufacturing, especially feeders. Kindly inform me where a quotation can be obtained for furnishing a Brooke feeder.

No. 34—We contemplate installing automatic machines and flowing devices.

Foreign Trade Opportunities

Recent issues of the Daily Consular and Trade Reports issued by the Bureau of Foreign and Domestic Commerce, Washington, D. C., list the following items. Further information concerning any of them may be obtained from the Bureau or its district offices by duly registered firms and individuals, by written request giving opportunity number.

Registration in the Importers' Index entitles the registered firm to receive further information concerning items listed in the Daily Commerce Reports. Registration may be obtained by making application to the Bureau of Foreign and Domestic Commerce, Washington, D. C., or to one of the district or cooperative offices located in nearly all of the large cities, and by filling out "form 57." Registered firms receive additional circulars and bulletins of various sorts relating to their particular line of business.

345277. The American representatives of a mercantile firm in Australia desires to purchase and secure an agency for the sale of lamp glasses or globes, etc. They also request samples and prices of glass and porcelain tableware. Purchase to be paid for in cash. Reference.

35316. A wholesale merchant in Italy desires to purchase, in large quantities, vacuum bottles for preserving the temperature of liquids. Quotations should be given c. i. f. Italian port. Terms: Cash against documents. References.

35327. A merchant in Mexico desires to be placed in communication with manufacturers of glass jars and bottles, and also with manufacturers of lithographed or engraved labels. No reference offered.

Monthly Summary of Foreign Commerce

No statement for the month of July having been issued by the Bureau of Foreign and Domestic Commerce at the time of going to press, the usual report is necessarily omitted from this issue.

Current Prices of Glass-Making Materials

From quotations furnished by various manufacturers and dealers

August 26, 1921

	Carlots	Less Carlots
Alumina hydrate ..... lb.	.06	.07
Arsenic trioxide (dense white, 99%) ..... lb.	.06	.06½–.06¾
Barium carbonate ..... ton	55.00	60.00
Bone ash ..... lb.	.04	.04½
Borax ..... lb.	.05¼-.05½	.05½-.06
Borax, fused, any mesh..... lb.	.19	.20
Boric acid, fused ..... lb.	.35	.35
Cadmium sulphide, red or orange ..... lb.		1.60
Cadmium sulphide, yellow.... lb.		1.80
Cobalt oxide ..... bbls. lb.		2.00
Cobalt oxide..... 10 lb. tins, lb.		2.10–2.25
Copper oxide, red..... lb.		.17– .20
Copper oxide, black..... lb.	.23	.26
Feldspar, 100 mesh ..... ton	18.00	
Fluorspar, powdered white, 90% ..... ton	40.00	
Kaolin ..... ton	25.00	35.00
Kryolite ..... lb.		.15
Lead oxide (red lead, Pb_3O_4) lb.	.08	.08
Litharge (PbO) ..... lb.	.07½	.07½
Lime—		
Hydrated ..... ton	45.00	
Burnt, ground, in bulk..... ton	7.50	
Burnt, ground, in paper sacks ..... ton	9.50	
Burnt, ground, in 280 lb. bbls per bbl.		2.05
Manganese (85% MnO_2) .... lb.	.03½	.04 –.06½
Nickelic oxide (NiO) black... lb.		.35
Nickelous oxide (Ni_2O) green lb.		.38
Potassium carbonate—		
Calcined 90% ..... lb.	.04½	.05
Hydrated 90% ..... lb.	.05	.06
Potassium nitrate ..... lb.	.09½	.09¾
Powdered blue ..... lb.		.24–.26
Salt cake, for glassmakers.. ton	25.00	.01½–.02 lb.

Current Prices—(Continued)

	Carlots	Less Carlots
Selenium ..... lb.		1.95–2.25
Soda ash, 58% dense, 48% basis		
Bulk ..... 100 lb.	1.55	1.60
Bulk, on contract..... 100 lb.	1.55	
Sodium nitrate, refined..... lb.	.05¼	.05½
Sodium selenite ..... lb.		2.25
Sulphur (flowers) ..... lb.	.02¼	.02¾
Sulphur (flour, heavy)..... lb.	.02	.02¼
Uranium oxide.... 100 lb. lots, per lb.		2.10–2.25
Zinc oxide (ZnO)..... lb.	.07½	.07¾

Stock Quotations

(Reported by Moore, Leonard & Lynch, Frick Building, Pittsburgh, Pa.)

Pittsburgh Stock Exchange—August 26

	Bid	Ask	Last
American Window Glass Machine Com.	55	61	60
American Window Glass Machine Pref.		75	75
American Window Glass Pref.....		95	95
Pittsburgh Plate Glass	116	..	116
U. S. Glass	31	35	33

Market dull, prices firm.

Wheeling Stock Exchange—August 26

	Bid	Ask	Last
Fostoria Glass Company	100	105	105
Hazel Atlas Glass Company.....	140	145	145
Imperial Glass Company	88	100	100
Central Glass Company	140	150	150

Market dull and weak.

Toledo Stock Exchange—August 26

	Bid	Ask	Last
Libbey-Owens Sheet Glass Com.....	100	108	108
Libbey-Owens Sheet Glass Pref.....	85	90	90
Owens Bottle Machine Com.....	27	29	29
Owens Bottle Machine Pref.....		No market	

Market dull and weak.

THE GLASS INDUSTRY CLASSIFIED BUYERS' GUIDE

ANNEALING FURNACES (See Lehrs)

ANTIMONY OXIDE
Harshaw, Fuller & Goodwin Co., The, Cleveland, O.

ARSENIC
Harshaw, Fuller & Goodwin Co., The, Cleveland, O.

AUTOMATIC BOTTLE MACHINERY (See Glass Working Machinery)

AUTOMATIC CONVEYORS AND LEHR FEEDERS
Automatic Machinery Co., Terre Haute, Ind.
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
Simplex Engineering Co., Washington Trust Building, Washington, Pa.

AUTOMATIC GLASS FEEDERS (See Glass Feeders)

AUTOMATIC GLASS WORKING MACHINERY (See Glass Working Machinery)

BATCH HANDLING AND MIXING SYSTEMS
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
Simplex Engineering Co., Washington Trust Bldg., Washington, Pa.

BINS, STORAGE (See Storage Bins and Steel Bins)

BLOCKS, HEAT INSULATING
Celite Products Co., 11 Broadway, New York.

BOILER FEED WATER PURIFICATION SYSTEMS
Scaife, Wm. B., & Sons Co., Pittsburgh, Pa.

BOILER INSULATION (See Insulating Brick)

BOND CLAY
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
Laclede-Christy, St. Louis, Mo.

BOTTLE-MAKING MACHINERY (See Glass Working Machinery)

BOXES, CORRUGATED FIBRE
Hinde & Dauch Paper Company, The, 408 Water St., Sandusky, Ohio.

BRICK (See Insulating Brick, and Fire Brick)

BRICK, SEMI-REFRACTORY
Celite Products Co., 11 Broadway, New York.

BURNERS (See Gas Burners)

CEMENT
High Temperature
Laclede-Christy, St. Louis, Mo.
Semi-Refractory
Celite Products Co., 11 Broadway, New York.
Heat Insulating, Waterproofing
Celite Products Co., 11 Broadway, New York.

CHEMICALS, GLASS-MAKERS'
Drakenfeld, B. F., & Co., Inc., New York.
Harshaw, Fuller & Goodwin Co., The, Cleveland, O.

CHIMNEYS (See Also Steel Stacks)
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
Simplex Engineering Co., Washington Trust Bldg., Washington, Pa.
Wiederholdt Construction Co., 625 Bank of Commerce Bldg., St. Louis, Mo.

CHROME OXIDE
Drakenfeld, B. F., & Co., Inc., New York.

CLAY (See Bond Clay, Fire Clay, Furnace Clay, Pot Clay)

CLAY POTS
Laclede-Christy, St. Louis, Mo.
Willetts Company, The, Pittsburgh, Pa.

COAL HANDLING AND STORAGE SYSTEMS
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
Simplex Engineering Co., Washington Trust Building, Washington, Pa.

COBALT OXIDE
Drakenfeld, B. F., & Co., Inc., New York.
Harshaw, Fuller & Goodwin Co., The, Cleveland, Ohio.

CONTRACTORS
Glass Factory, Furnace Construction and Repairs
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
McCamic-Batchell-Bergman Co., Box 6, Station G, Toledo, Ohio.
Russell Engineering Company, St. Louis, Mo.
Simplex Engineering Co., Washington Trust Building, Washington, Pa.

COPPERAS
Harshaw, Fuller & Goodwin Co., The, Cleveland, O.

COPPER OXIDE, BLACK
Harshaw, Fuller & Goodwin Co., The, Cleveland, O.

DECOLORIZERS
Drakenfeld, B. F., & Co., Inc., New York.
Harshaw, Fuller & Goodwin Co., The, Cleveland, Ohio.

DECORATING MATERIALS, GLASS
Harshaw, Fuller & Goodwin Co., The, Cleveland, Ohio.

EMERY
Niagara Emery Mills, Inc., 50 Broad St., New York.

WHEN asking for prices or other information you will favor both advertiser and publisher by mentioning *The Glass Industry.*

ENGINEERS
Chimney and Power Plant
Simplex Engineering Co., Washington Trust Bldg., Washington, Pa.
Wiederholdt Construction Co., 625 Bank of Commerce Bldg., St. Louis, Mo.
Fuel and Furnace
Chapman Engineering Co. Division, Mt. Vernon, Ohio.
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
Russell Engineering Company, St. Louis, Mo.
Simplex Engineering Co., Washington Trust Bldg., Washington, Pa.
Glass Factory
Cruikshank, J. W., Engineering Co., 230 Fifth Ave., Pittsburgh, Pa.
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
McCamic-Batchell-Bergman Co., Box 6, Station G, Toledo, Ohio.
Russell Engineering Company, St. Louis.
Simplex Engineering Co., Washington Trust Building, Washington, Pa.
Mechanical and Structural
Cruikshank, J. W., Engineering Co., 230 Fifth Ave., Pittsburgh, Pa.
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
Plate Glass Factory
Cruikshank, J. W., Engineering Co., 230 Fifth Ave., Pittsburgh, Pa.
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
Producer Gas
Chapman Engineering Co. Division, Mt. Vernon, Ohio.
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
Simplex Engineering Co., Washington Trust Bldg., Washington, Pa.
Standard Mfg. Co., Corning, N. Y.

ENGINES
Gas and Corliss
Cooper, C. & G., Co., Mt. Vernon, Ohio.

FEEDER BLOCKS
Laclede-Christy, St. Louis, Mo.

FEEDERS, AUTOMATIC GLASS (See Glass Feeders)

FELDSPAR
Drakenfeld, B. F., & Co., Inc., New York.
Harshaw, Fuller & Goodwin Co., The, Cleveland O.

FILTERS, WATER
Scaife, Wm. B., & Sons Co., Pittsburgh, Pa.

FIRE BRICK (See also Refractories)
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
Laclede-Christy, St. Louis, Mo.

FIRE CLAY
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
Laclede-Christy, St. Louis, Mo.

FLOATING AGITATORS
Chapman Engineering Co. Division, Mt. Vernon, Ohio.
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.

FUEL ENGINEERS (See Engineers)

FUEL GAS PLANTS, GASOLINE
Tirrill Gas Machine Lighting Co., 50 Church St., New York.

FURNACE CLAY
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
Laclede-Christy, St. Louis, Mo.

FURNACE ENGINEERS (See Engineers)

FURNACE INSULATION (See Insulating Brick)

FURNACE REPAIR MATERIALS
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
Laclede-Christy, St. Louis, Mo.
McCamic-Batchell-Bergman Co., Box 6, Station G, Toledo, Ohio.

FURNACES
Annealing (See Lehrs)
Tank and Pot
Chapman Engineering Co. Division, Mt. Vernon, Ohio.
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
McCamic-Batchell-Bergman Co., Box 6, Station G, Toledo, Ohio.
Russell Engineering Company, St. Louis, Mo.
Simplex Engineering Co., Washington Trust Building, Washington, Pa.

GAS BURNERS
Producer Gas
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
McCamic-Batchell-Bergman Co., Box 6, Station G, Toledo, Ohio.
Simplex Engineering Co., Washington Trust Bldg., Washington, Pa.

GAS ENGINES (See Engines)

GAS MAINS, STEEL
Standard Mfg. Co., Corning, N. Y.

GASOLINE FUEL GAS PLANTS
Tirrill Gas Machine Lighting Co., 50 Church St., New York.

GAS PRODUCERS (See Producer Gas Plants and Fuel Gas Plants)

GAS REVERSING VALVES (See Reversing Valves)

GLASS DECORATING MATERIALS
Harshaw, Fuller & Goodwin Co., The, Cleveland, Ohio.

GLASS FEEDER BLOCKS
Laclede-Christy, St. Louis, Mo.

GLASS FEEDERS, AUTOMATIC
Miller Glass Engineering Co., Swissvale, Pa.

GLASSHOUSE MACHINERY AND EQUIPMENT (See also Glass Working Machinery)
Automatic Machinery Co., Terre Haute, Ind.
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
Miller Glass Engineering Co., Swissvale, Pa.
Simplex Engineering Co., Washington Trust Building, Washington, Pa.

GLASSHOUSE TOOLS
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.

GLASS PLANTS, COMPLETE INSTALLATIONS
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
McCamic-Batchell-Bergman Co., Box 6, Station G, Toledo, Ohio.
Russell Engineering Co., St. Louis, Mo.
Simplex Engineering Co., Washington Trust Bldg., Washington, Pa.

GLASS SAND
United States Silica Co., 1960 Peoples Gas Bldg., Chicago, Ill.

GLASS WORKING MACHINERY
Automatic and Semi-Automatic Bottle Blowing, Electric Presses, etc.
Miller Glass Engineering Co., Swissvale, Pa.
O'Neill Machine Co., The, Toledo, Ohio.
O'Neill Machine Co., The, Albany Works, Trenmar Gardens, Willesden Junction, London, N. W. 10, England.

HEAT INSULATING MATERIALS (See Insulating Brick, Powder, Heat Insulating; Blocks, Heat Insulating)

HIGH TEMPERATURE CEMENT (See Cement)

INDICATING PYROMETERS
Wilson-Maeulen Co., Inc., 385 Concord Ave., New York.

INSULATING BRICK, FURNACE AND BOILER
Celite Products Company, 11 Broadway, New York.
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.

INSULATION
Heat
Celite Products Co., 11 Broadway, New York.
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
Cork Block
Celite Products Co., 11 Broadway, New York.

LEHR FEEDERS (See Automatic Conveyors and Lehr Feeders)

LEHRS
Muffle
Dixon, H. L., Co., Box 140, Pittsburgh, Pa.
Simplex Engineering Co., Washington Trust Building, Washington, Pa.

LEPIDOLITE
Drakenfeld, B. F., & Co., Inc., New York.

MACHINERY, GLASS WORKING (See Glass Working Machinery)

MANGANESE
Harshaw, Fuller & Goodwin Co., The, Cleveland, Ohio.

MIXERS, BATCH (See Batch Handling and Mixing Systems)